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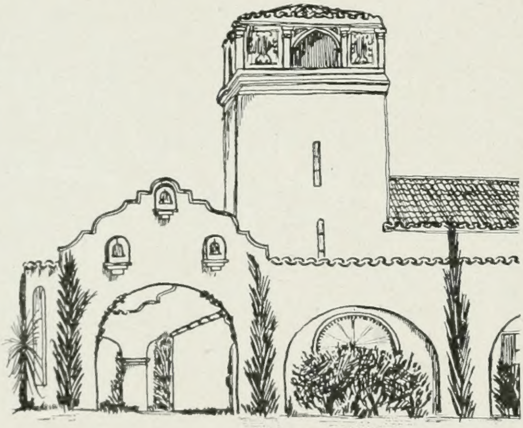

COLLEGE OF OSTEOPATHIC PHYSICIANS
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HUMAN ANATOMY

MORRIS

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SECOND EDITION.

OSTEOLOGY. By **J. Bland Sutton**, F.R.C.S., Examiner in Anatomy in Royal College of Surgeons; Lecturer on Comparative Anatomy, and Senior Demonstrator of Anatomy, Middlesex Hospital.

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HUMAN ANATOMY

A COMPLETE SYSTEMATIC TREATISE

BY VARIOUS AUTHORS

INCLUDING A SPECIAL SECTION ON SURGICAL AND TOPOGRAPHICAL ANATOMY

EDITED BY

HENRY MORRIS, M.A. AND M.B. LOND.

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BY SEVEN HUNDRED AND NINETY WOODCUTS

THE GREATER PART OF WHICH ARE ORIGINAL AND MADE EXPRESSLY FOR THIS WORK BY SPECIAL ARTISTS

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TO THE SECOND EDITION

The same, with ARTHUR ROBINSON in place of H. ST. JOHN BROOKS and also in place of ARTHUR HENSMAN

EDITOR'S PREFACE TO THE FIRST EDITION.

This Treatise on Human Anatomy is designed for the use of Students preparing for the Conjoint Board of the Royal Colleges of Physicians and Surgeons, for the Fellowship of the Royal College of Surgeons, and for the Examinations in Anatomy at the various Universities.

It aims at being a complete and systematic description of every part and organ of the human body so far as it is studied in the dissecting room.

Histology and development—except the mode and dates of development of the bones, and in a few other instances—are not included, as it is felt that these subjects are more appropriately dealt with in books on Physiology than they can conveniently be in works on Anatomy.

The different sections have been written by separate Authors, who are known to have devoted special attention to the subjects allotted to them. To these gentlemen my best thanks are due for their generous assistance and able co-operation.

Whilst each Author is alone responsible for the subject-matter of the article which follows his name, the proof-sheets of other articles besides his own have in certain cases been submitted to him, so that several of the articles may be considered to have received the approval and endorsement of two, three, or more Authors. This has been particularly the case with the sections on Osteology, Arthrology, Myology, and Neurology. There is, therefore, reason to believe that such important points as the attachments of ligaments and of muscles, and the nerve-supply of muscles, etc., will be found to be in perfect accord in the various sections in which they are referred to or described.

In the illustrations of the bones, the origins of muscles are indicated by red lines, the insertions by blue lines, and the attachments of ligaments by dotted black lines.

A feature of the book which, it is confidently hoped, will facilitate the work of students, is the mode of describing the illustrations.

This plan was decided upon at a conference of all the Authors and one of the artists. It consists in printing the descriptions in different types at the end of the pointers. Thus it will be found that muscles, fasciæ, and ligaments are in one kind of type; arteries, veins, and lymphatics in another; bones in a third; and nerve-structures in a fourth. The names of special organs—such as the liver, lungs, etc.—are printed in the same type as the bones, so as to avoid too great a variety of lettering.

Several of the illustrations are repeated in different parts of the book, with the object of sparing the reader the trouble of referring from one section to another when reference is made in the letterpress to such figures.

As much uniformity as possible has been observed in the size and general style of the drawings; but exceptions will be found in the section on Surgical and Topographical Anatomy, for which many of the illustrations have been borrowed from another work, published by Messrs. J. and A. Churchill, namely, Bellamy's 'Surgical Anatomy.'

I have to acknowledge with grateful thanks the assistance I have received from Mr. GORDON BRODIE, who made several dissections from which drawings were taken; from Mr. J. BLAND SUTTON and Mr. FRANK STEELE in reading over proof-sheets; from Mr. BURGHARD for the care with which he has drawn up the Index and Tables of Contents; and from all the artists named on the title-page.

Mr. BERJEAU and Mr. BALCOMB have drawn a very large proportion of the figures; and, with Mr. SMIT and Mr. PARKER, have shown a degree of interest in, and given an amount of time and trouble to the illustrations for which they merit the fullest recognition.

The beautiful anatomical dissections in the Hunterian Museum which have been, by permission, copied for this Treatise are from the hand of Mr. WILLIAM PEARSON, to whose great skill in dissecting I have much pleasure in referring.

Too much praise cannot be given to all engaged in the actual printing of the book for the painstaking care they have devoted to it; especially to the difficult and precise work of properly 'registering' and printing the coloured illustrations.

I need only say, in conclusion, that I shall not consider my prolonged and laborious task has been in vain if it be found that the Treatise adequately meets the requirements of Students, for whom it is written.

HENRY MORRIS.

8 CAVENDISH SQUARE: *January* 1893.

PREFACE TO THE SECOND EDITION.

In preparing this Edition the work has been carefully, and it is hoped thoroughly, revised, both in regard to the descriptive text and the illustrations. Some new cuts have been added, and in a few instances new ones have been substituted for those in the First Edition.

A description of the Skin has been added by Mr. Anderson ; and an additional section at the end of the volume, on "Vestigial and Abnormal Structures," has been supplied by the pen of Dr. Robinson.

The Editor has been fortunate in obtaining the assistance of the original authors of the various sections in all cases but two. Dr. Arthur Robinson has revised the section on the Nervous System instead of Dr. H. St. John Brooks ; and also those which were written by the late Mr. Arthur Hensman.

The Editor has to thank many kind friends, and others personally unknown to him, both in the United Kingdom and in America, for numerous and valuable suggestions, and for corrections of typographical errors, which regrettably but almost unavoidably had crept into the first edition. Great attention has been given to all of these suggestions. Many of them have been adopted, and, if all have not been, it is because they were not in accord with the object and intention of the work. For instance, one friendly critic thinks that in order to make it complete as a text-book the Minute Anatomy of the Viscera must be added ; this would be entirely inconsistent with our aim, which is to make the book complete as "a systematic description of every part and organ of the human body as it is studied in the dissecting room." Minute anatomy must be studied, of course ; but in the histological laboratory, not in the dissecting room, or at the demonstrator's classes on Topographical Anatomy.

It is hoped that this revised edition will receive the confidence of the Teachers, and find favour with the Students whose labours the book is intended to facilitate.

CAVENDISH SQUARE, LONDON : *September 7, 1898.*

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SECTION I

OSTEOLOGY

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THE SKELETON

THE **skeleton** contains 206 distinct **bones.** They are arranged by anatomists in two sets:—the bones of the **trunk** and the bones of the **limbs.** The skeleton of the trunk is made up of the **skull,** which contains twenty-nine bones exclusive of the teeth; the **vertebral column,** consisting of twenty-six separate bones; twenty-four **ribs,** and the **sternum.** The skeleton of the upper limbs comprises sixty-four bones; and that of the lower limbs, including the patellæ, sixty-two.

Several of the skull bones are **compound,** that is, in the immature skeleton they consist of separate elements which ultimately unite to form a single bone. In order to comprehend the nature of such bones, it is necessary to examine them in the various stages through which they pass in the embryo and child. Thus the student, anxious to convince himself of Man's place in nature, studies carefully the development and ossification of bones, and compares them with the bones of other Vertebrata. He then finds that many elements which make a compound bone are osteological units for the Comparative Anatomist.

Comparisons of this nature constitute the science of **Morphology,** one of the most fascinating departments of Biology.

It is the duty of the student to follow the descriptions with the actual bones in his hand. He should also remember that many variations occur in the outlines and markings of bones. Hence the various types described and figured represent the average of a large number of bones examined. It is very rare to meet with bones which accurately correspond to the description in every detail.

In order to appreciate the morphology of the skeleton, the **osteogenesis** or mode of development of bones must be studied as well as their **topography** or position. Some bones arise by **ossification in membrane,** others in **cartilage.** In the early embryo, many portions of the skeleton are represented by cartilage which becomes infiltrated by lime salts—**calcification.** This earthy material is taken up and redeposited in a regular manner—**ossification.** Portions of the original cartilage persist at the articular ends of bones, and, in young bones, at the **epiphysial** lines. Long bones increase in length at the **epiphysial cartilages,** and increase in thickness by ossification of the deeper layers of the investing membrane or **periosteum.** These processes—intercartilaginous and intermembranous ossification—proceed concurrently in the limb-bones of a young and growing mammal.

There is no bone in the human skeleton which, though pre-formed in cartilage, is perfected in this tissue. The ossification is completed in membrane. On the other hand, there are numerous instances in the skull, of bones the ossification of which begins in, and is perfected by, the intermembranous method. Ossification in a few instances commences in membrane, but later invades tracts of cartilage; occasionally the process begins in perichondrium and remains restricted to it, never invading the underlying cartilage, which gradually disappears as the result of continued pressure exerted upon it by the growing bone. The vomer and nasal bones are the best examples of this mode of development.

A CLASSIFIED LIST OF THE BONES TO SHOW THEIR MODE OF DEVELOPMENT

1. All the **limb-bones** and those of the **vertebral** column are pre-formed in cartilage and perfected in membrane, with the exception of the clavicles. These begin in membrane, proceed in cartilage, and are finally perfected in membrane.

2. **The Skull.**

MEMBRANE-BONES

Parietals.
Frontal.
Squamosals.
Maxillæ.
Malars.
Palates.
Nasals.

Interparietal portion of occipital.
Wormian bones and the epipterics.
Tympanics.
Mandible (except part near the symphysis).
Lachrymals.
Vomer.

CARTILAGE BONES

Sphenoid.
Petrosals.
Mallei.
Stapes.
Hyoid.
Inferior turbinals.

Occipital (except interparietal portion).
Ethmoid.
Incudes.
Styloid processes.
Symphysial portion of the mandible.
Internal pterygoid plate.

Many of the skull bones are **composite**, that is, they consist of two or more elements which remain separate in other vertebrates. To this group belong:—

The Occipital.
Temporals.
Ethmoid.

Maxillæ.
Hyoid.
Sphenoid.

Frontal.
Malars.
Mandible.

The details of the development and ossification of each bone are added to the description.

The **limb-bones** differ in several important particulars from those of the skull. Some of the long bones have many centres of ossification, but the centres are of very different morphological value from those of the skull. Speaking generally, it is only the primary nuclei that have any especial value for the morphologist. The **primary** nucleus of a long bone appears before birth. In only three instances does a **secondary** centre appear before birth; e.g. the condyles of the femur, the head of the tibia, and occasionally in the head of the humerus. Many **primary** ossific nuclei appear after birth; for example, those for the carpal bones, the cuneiform and scaphoid (navicular) bones of the foot, the coracoid process of the scapula, and the third, fourth and fifth pieces of the sternum.

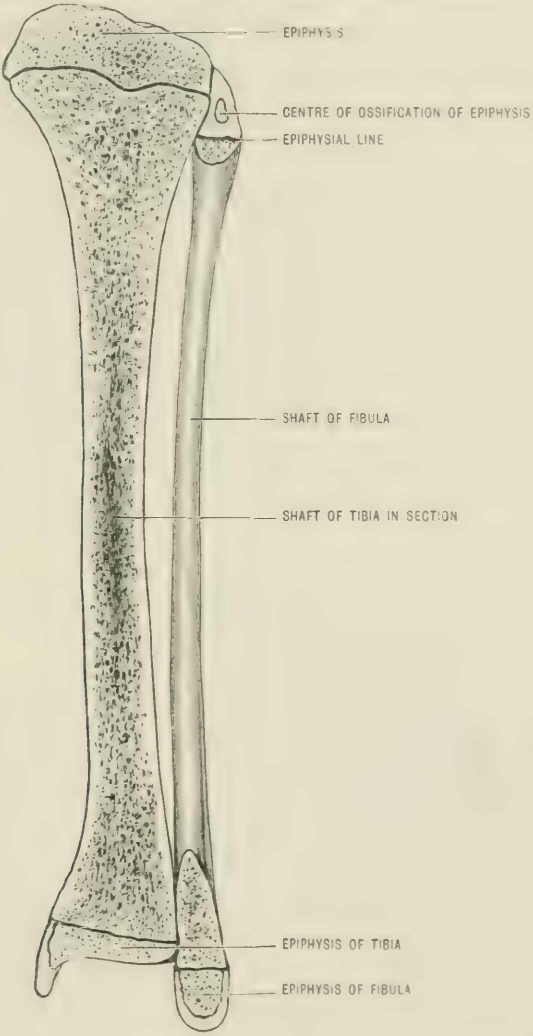
When a bone ossifies from one nucleus only, this nucleus may appear before or after birth. Examples: the astragalus at the seventh month of embryonic life, and the trapezoid at the eighth year. When a bone possesses one or more secondary centres, the primary nucleus, as a rule, appears early. Examples: the femur, humerus, phalanges, and the calcaneum.

Secondary centres which remain for a time distinct from the main portion of a bone are termed **epiphyses**. An epiphysis may arise from a single nucleus, as is the case with the lower end of the femur; or from several, as at the upper end of the humerus. Prominences about the ends of long bones may be capped by separate epiphyses, as is the case at the upper end of the femur. Epiphyses, though of no morphological value, seem to follow certain rules, thus:—

1. Those epiphyses which appear last are the first to unite with the shaft.

Exception.—The distal epiphysis of the fibula is visible three years before the proximal, but fuses with the shaft much earlier than it. It should be remembered that the proximal end of the fibula in man and many other mammals is vestigial.

Fig. 1.—The Tibia and Fibula in section to show the Epiphyses.


EPIPHYSIS
CENTRE OF OSSIFICATION OF EPIPHYSIS
EPIPHYSIAL LINE
SHAFT OF FIBULA
SHAFT OF TIBIA IN SECTION
EPIPHYSIS OF TIBIA
EPIPHYSIS OF FIBULA

2. The epiphysis towards which the nutrient artery is directed unites first with the shaft.

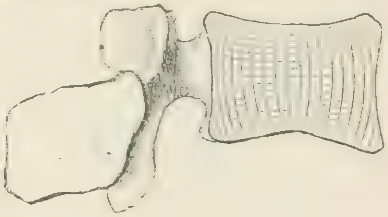
3. When a bone has only one epiphysis, the nutrient artery is directed towards the extremity which has no epiphysis.

4. The centres of ossification appear earliest for those epiphyses which bear the largest relative proportion to the shafts of the bones to which they belong.

5. When an epiphysis ossifies from more than one centre, the various nuclei coalesce before the shaft and epiphysis consolidate.

On section, the shaft of a fœtal long bone is found occupied with red marrow lodged in bony cells which do not present any definite arrangement. In an adult, the central portion of the shaft of a long bone is filled with fat, or marrow, held together by a delicate reticulum of connective tissue; the space containing the marrow is the *medullary cavity.* The expanded ends of the bone contain a network of cancellous tissue, the spaces being filled with *red marrow.* This cancellous tissue differs from that of the fœtal bone in that it is arranged in a definite manner according to the direction of pressure and the tension exerted by muscles. Pressure lines are well shown in the vertebræ. In a vertical section through the centrum of a vertebra the fibres of the cancellous tissue are seen to be arranged vertically and horizontally; the vertical fibres are curved with their concavities directed towards the centre of the bone. The horizontal fibres are slightly curved parallel with the upper and lower surfaces, with their convexities towards the centre of the bone. They are not so defined as the vertical set. (Wagstaffe.)

FIG. 2.—A VERTEBRAL CENTRUM IN SECTION TO SHOW THE PRESSURE CURVES.



The arrangement of the cancelli in individual bones is a consequence of the mechanical conditions to which the bone is subject. This is well illustrated in the femur. In the upper end of this bone, the cancellous tissue is arranged in divergent curves. One set springs from the inner wall and spreads into the greater trochanter; a second series of curves crosses this and forms a set of Gothic arches, and is continued into the neck and head; a third set springs from the lower thick wall of the neck and spreads into the upper part of the head, and ends perpendicularly in the articular surface mainly along the lines of greatest pressure. A

FIG. 3.—A DIAGRAM TO SHOW THE PRESSURE AND TENSION CURVES OF THE FEMUR. (After Wagstaffe.)

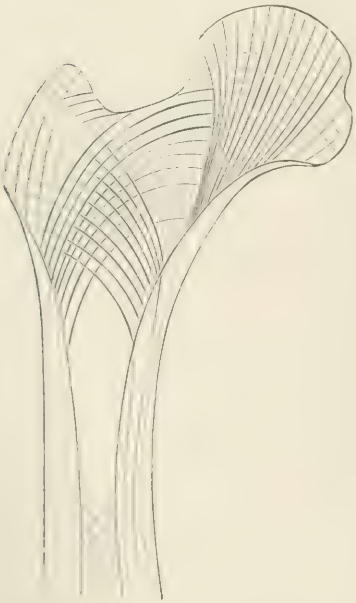
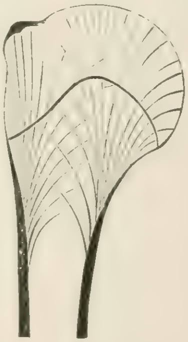


FIG. 4.—A DIAGRAM SHOWING PRESSURE AND TENSION CURVES IN THE HEAD OF THE HUMERUS. (After Wagstaffe.)



nearly vertical plane of compact tissue projects into the neck of the bone from the inferior cervical tubercle towards the great trochanter. This is placed in the line through which the weight of the body falls, and adds to the stability of the neck of the bone: it is said to be liable to absorption in old age. In the lower end of the bone, the vertical and horizontal fibres are so disposed as to form a rectangular meshwork.

The plan of construction exhibited by the femur is the most complex in the skeleton, but the principles involved are the same in all bones. An interesting disposition of these curves is exhibited in the head of the humerus. The pressure curves radiate in two directions: one set at right angles to the articular surface of the head of the bone; the other at right angles to the greater tuberosity. The last set, like those in the greater trochanter, are the result of **tension** exerted by the muscles attached to these prominences.

The **shafts** of long bones at the time of birth are mainly cylindrical and free from ridges. The majority of the lines and ridges so conspicuous on the shafts of long bones in adults are due to the ossification of muscle-attachments. The more developed the muscles, the larger the ridges become.

The surfaces of bones are variously modified by environing conditions. Pressure at the extremities causes enlargement, and movement renders them smooth. The two causes combined produce an articular surface. When rounded and supported upon a constricted portion of bone, an articular surface is termed a **head,** sometimes a **condyle**; when depressed, a **glenoid fossa.** Blunt, non-articular processes are called **tuberosities**; smaller ones, **tubercles**; sharp projections, **spines.** Slightly elevated ridges of bones are **crests**; when narrow and pronounced, **lines** and **borders.** A shallow depression is a **fossa**; when narrow and deep, a **groove**; a perforation is usually called a **foramen.** The majority of terms—such as **canal, spine, notch, sulcus,** and the like—are so obvious as to render explanation needless.

THE SPINE

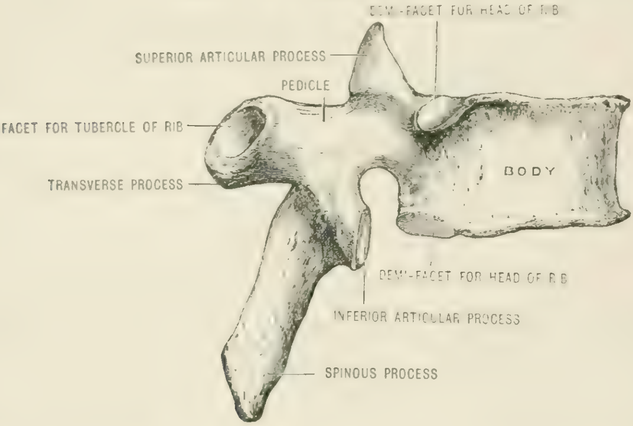
The **spine** (vertebral column) consists of thirty-three superimposed bones termed **vertebræ.** Of these the upper twenty-four remain separate throughout life and form three groups. The first seven are called **cervical,** the succeeding twelve **thoracic** (dorsal), and the next five **lumbar.** In adult life the last nine vertebræ ankylose to form two composite bones named the **sacrum** and the **coccyx.** The sacrum is formed by the fusion of five vertebræ from the twenty-fifth to the twenty-ninth inclusive; the four terminal are vestigial, and form the coccyx. In order to gain a general notion of the characters of a vertebra, it is desirable to select a bone from the middle of the thoracic series.

A vertebra consists of a body and an arch: The **body** or **centrum** is a solid disc of bone slightly concave on its superior and inferior aspects, and wider transversely than antero-posteriorly. The upper and lower surfaces are rough for intervertebral discs, and the margins are slightly lipped. The circumference of the body is, in front, concave vertically, but convex from side to side; posteriorly it is excavated, and presents foramina for the escape of veins from the cancellous tissue. On the sides of the body, at the upper and lower angles, there are four demi-facets; when two vertebræ are superimposed, the adjacent demi-facets form a complete articular facet for the head of a rib.

The **arch** is formed by two pedicles and two laminæ, and has connected with it seven processes—one spinous, two transverse and four articular. The **pedicles** are two constricted short piers of bone projecting horizontally backwards from the upper angles of the posterior surface. The lower border of each pedicle is deeply notched; hence, when two vertebræ are in position the notches are converted into intervertebral foramina for the transmission of spinal nerves and vessels.

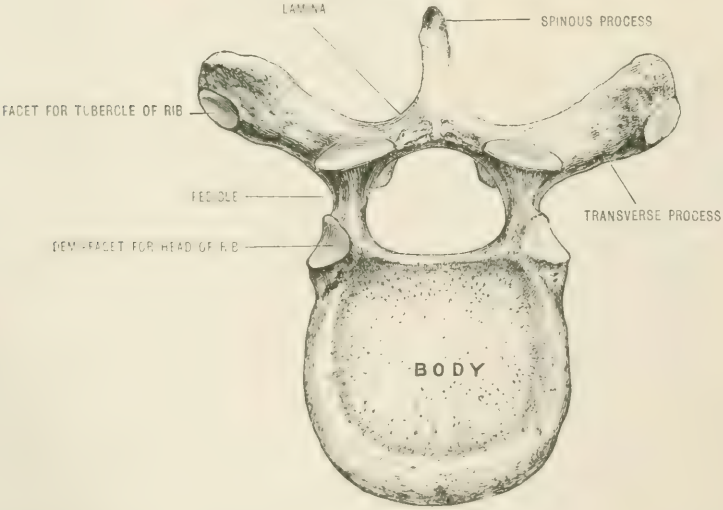
The **laminæ** are broad plates of bone continuous with the pedicles; each lamina meets its fellow dorsally to complete the **neural arch,** and conjointly form the **spinous process.** The superior borders of the laminæ are rough for the insertion of ligamenta subflava. The anterior surface, in its upper part, is smooth where it bounds the neural canal. The lower part is rough for the origin of the ligamenta subflava. This rough surface is continuous with the inferior border of the spinous process.

Fig. 5.—A Thoracic Vertebra. (Side view.)


DEMI-FACET FOR HEAD OF RIB
SUPERIOR ARTICULAR PROCESS
PEDICLE
FACET FOR TUBERCLE OF RIB
TRANSVERSE PROCESS
BODY
DEMI-FACET FOR HEAD OF RIB
INFERIOR ARTICULAR PROCESS
SPINOUS PROCESS

The **spinous process** projects backwards and downwards from the confluent laminæ. To its upper and lower borders the interspinous ligaments are attached; its tip is rounded for the supraspinous ligament. It is mainly a muscular process.

Fig. 6.—A Thoracic Vertebra.


LAMINA
SPINOUS PROCESS
FACET FOR TUBERCLE OF RIB
PEDICLE
TRANSVERSE PROCESS
DEMI-FACET FOR HEAD OF RIB
BODY

The **articular processes** are four in number: two are superior; they spring from the junction of the pedicles with the laminæ and have their articular facets directed backwards, with a slightly outward tendency; their anterior surfaces complete the intervertebral foramina; posteriorly their margins give attachment to capsular ligaments. The inferior articular processes are slightly concave oval facets on the lower and outer angles of the anterior surfaces of the laminæ. They are directed forwards and slightly inwards.

The **transverse processes** are two in number, and jut outwards from the pedicles and laminæ between the superior and inferior articular processes. The tip presents an oval facet for articulation with the tubercle of the rib. When the rib is *in situ*, its neck forms with the process a **costo-transverse** foramen. The transverse processes, in addition to supporting the ribs, afford powerful leverage to muscles.

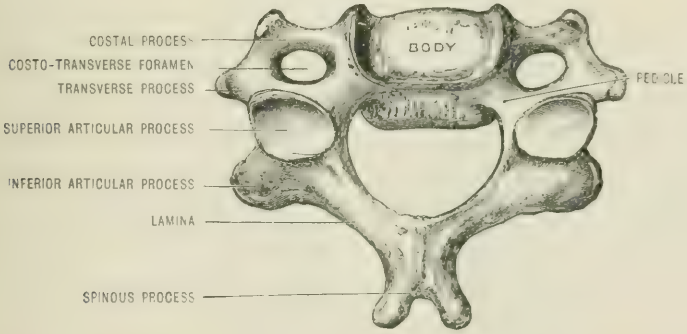
THE CERVICAL VERTEBRÆ

A typical cervical vertebra (from the third to sixth inclusive) presents the following characters: The centrum is smaller than in other regions of the column, and is of oval shape, the major axis being transverse. The upper surface has its lateral margins raised into prominent lips, whilst the lower surface is somewhat concave, its anterior margin being lipped so as to slightly overlap the anterior surface of the vertebra below. The inferior lateral margins are rounded, and come into relation with the raised edges of the centrum next below.

The **pedicles** are directed obliquely outwards, and the intervertebral notch is narrower above than below. The **laminæ** are long and narrow. The spinous process is short, and bifid at the extremity.

Articular processes.—Both the upper and lower articular processes are situated at the junction of the pedicle with the laminæ and they form the upper and lower extremities of a small column of bone. The facets of the upper processes look backwards and upwards and those of the lower processes forwards and downwards.

Fig. 7.—A Cervical Vertebra.



The **transverse** process presents near its base the **costo-transverse** foramen for the transmission of the vertebral artery, vein, and a plexus of sympathetic nerves. The process behind the foramen has a shallow groove for the corresponding spinal nerve. The extremity of the transverse process is bifid: each arm is terminated by a tubercle referred to as anterior and posterior. The **costo-transverse** foramen is very characteristic of a cervical vertebra. It is bounded internally by the pedicle, posteriorly by the transverse process, anteriorly by the costal process, and externally by the costo-transverse lamella which runs obliquely upwards and forwards in the upper vertebræ and horizontally in the lower.

The **spinal foramen** of all the cervical vertebræ is large, and somewhat triangular in form.

Peculiar cervical vertebræ.—The various cervical vertebræ possess distinguishing features. The first, second, and seventh have characters so different from their fellows as to render them peculiar.

The Atlas or First Cervical Vertebra

This vertebra has neither body nor spinous process: it is an irregular ring of bone with two thicker portions, the **lateral masses**, united anteriorly by a bridge, the **anterior arch**, which constitutes one-fifth of the entire circumference. This arch presents a **tubercle** on its anterior face for the anterior vertebral ligament and the *longus colli muscle*; its posterior surface has a circular facet for the odontoid process of the axis. The upper and lower borders are for ligaments.

The **lateral** masses are united posteriorly by a larger arch of bone, forming two-fifths of the circumference. Posteriorly this arch has a tubercle, representing a rudimentary spinous process. The upper and under surfaces of the arch afford attachments to ligaments. At the junction of the posterior arch with the lateral masses there is, on the upper surface, a deep groove which lodges the vertebral artery and the suboccipital (first spinal) nerve. A bridge of bone (the ossified oblique ligament) sometimes converts this into a foramen. A similar, but much shallower, notch is present on the under surface; this, with the axis, forms an intervertebral foramen for the second nerve. The atlas and axis are peculiar in that the first and second spinal nerves issue behind the articular processes, whereas the remaining spinal nerves emerge in front of the articular facets of the vertebræ. Each **lateral** mass has, on its upper surface, an elongated, deeply concave articular fossa or cup. These articular cups converge anteriorly. Occasionally each presents two oval facets united by an isthmus. These cups receive the occipital condyles and permit nodding movements of the head. The inferior articular processes are circular and almost flat; they are directed downwards, with an inclination inwards, rest upon the axis, and permit rotatory movements of the head. Between the upper and lower articular surfaces on the inside of the ring, two **tubercles** exist for the transverse ligament. This ligament divides the space within the ring into an anterior smaller segment for the odontoid process of the axis, and a larger portion —the **spinal foramen** of other vertebræ—for the spinal cord and its membranes.

FIG. 8.—THE FIRST CERVICAL VERTEBRA OR ATLAS.

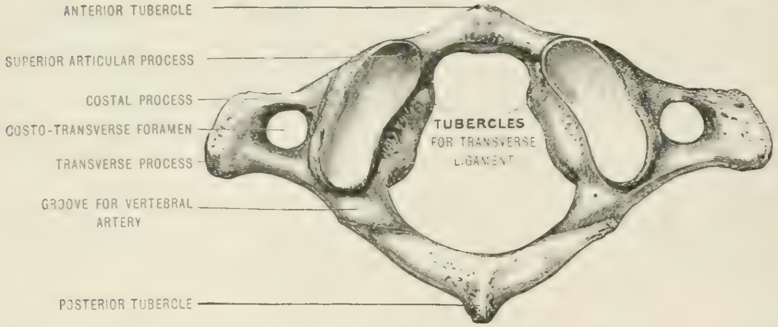
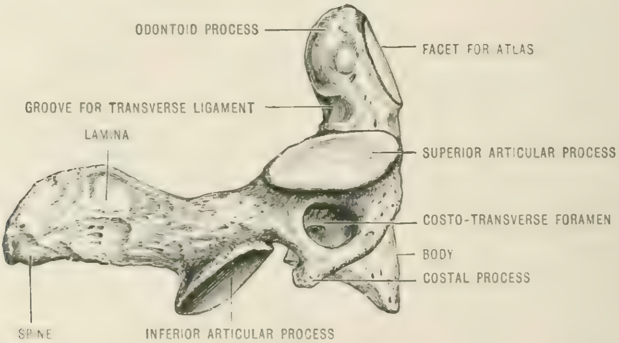

ANTERIOR TUBERCLE
SUPERIOR ARTICULAR PROCESS
COSTAL PROCESS
COSTO-TRANSVERSE FORAMEN
TRANSVERSE PROCESS
GROOVE FOR VERTEBRAL ARTERY
POSTERIOR TUBERCLE
TUBERCLES FOR TRANSVERSE LIGAMENT

FIG. 9.—THE AXIS.


ODONTOID PROCESS
FACET FOR ATLAS
GROOVE FOR TRANSVERSE LIGAMENT
LAMINA
SUPERIOR ARTICULAR PROCESS
COSTO-TRANSVERSE FORAMEN
BODY
COSTAL PROCESS
SPINE
INFERIOR ARTICULAR PROCESS

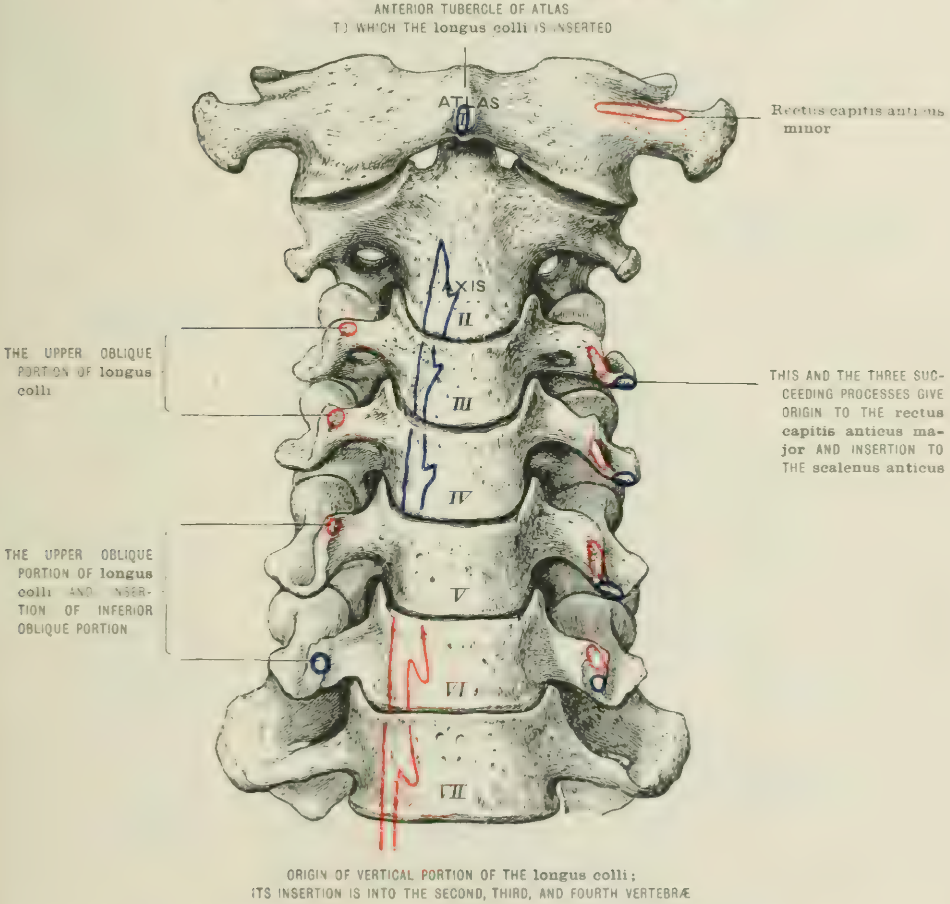
The **transverse processes** are large, to serve for the attachment of muscles which help to rotate the head. The **costo-transverse** foramina are large, but the **costal processes** are slender.

THE AXIS OR SECOND CERVICAL VERTEBRA

The **Axis** is easily recognised by the large rounded odontoid process which surmounts its upper surface. The **centrum** has a more prominent lip than the other cervical vertebræ, and the anterior surface has a median ridge separating two **lateral depressions**.

The **odontoid process** is an irregularly rounded peg of bone. The anterior surface has an oval facet for the anterior arch of the atlas. Posteriorly it presents a deeply cut smooth groove for the transverse ligament. To the apex, a thin narrow fibrous band (the suspensory ligament) is attached. On each side of the apex there is an oblique facet for the check ligaments which connect it with the occipital bone. The **pedicles** are stout and broad; they support the oval, upwardly directed, articular surfaces for the atlas. The inferior **articular** surfaces do not differ from the cervical type. The **transverse** are smaller than the **costal processes.**

FIG. 10.—THE CERVICAL VERTEBRÆ. (Anterior view.)


ANTERIOR TUBERCLE OF ATLAS
TO WHICH THE longus colli IS INSERTED
ATLAS
Rectus capitis anticus minor
AXIS
II
THE UPPER OBLIQUE PORTION OF longus colli
III
THIS AND THE THREE SUCCEEDING PROCESSES GIVE ORIGIN TO THE rectus capitis anticus major AND INSERTION TO THE scalenus anticus
IV
THE UPPER OBLIQUE PORTION OF longus colli AND INSERTION OF INFERIOR OBLIQUE PORTION
V
VI
VII
ORIGIN OF VERTICAL PORTION OF THE longus colli;
ITS INSERTION IS INTO THE SECOND, THIRD, AND FOURTH VERTEBRÆ

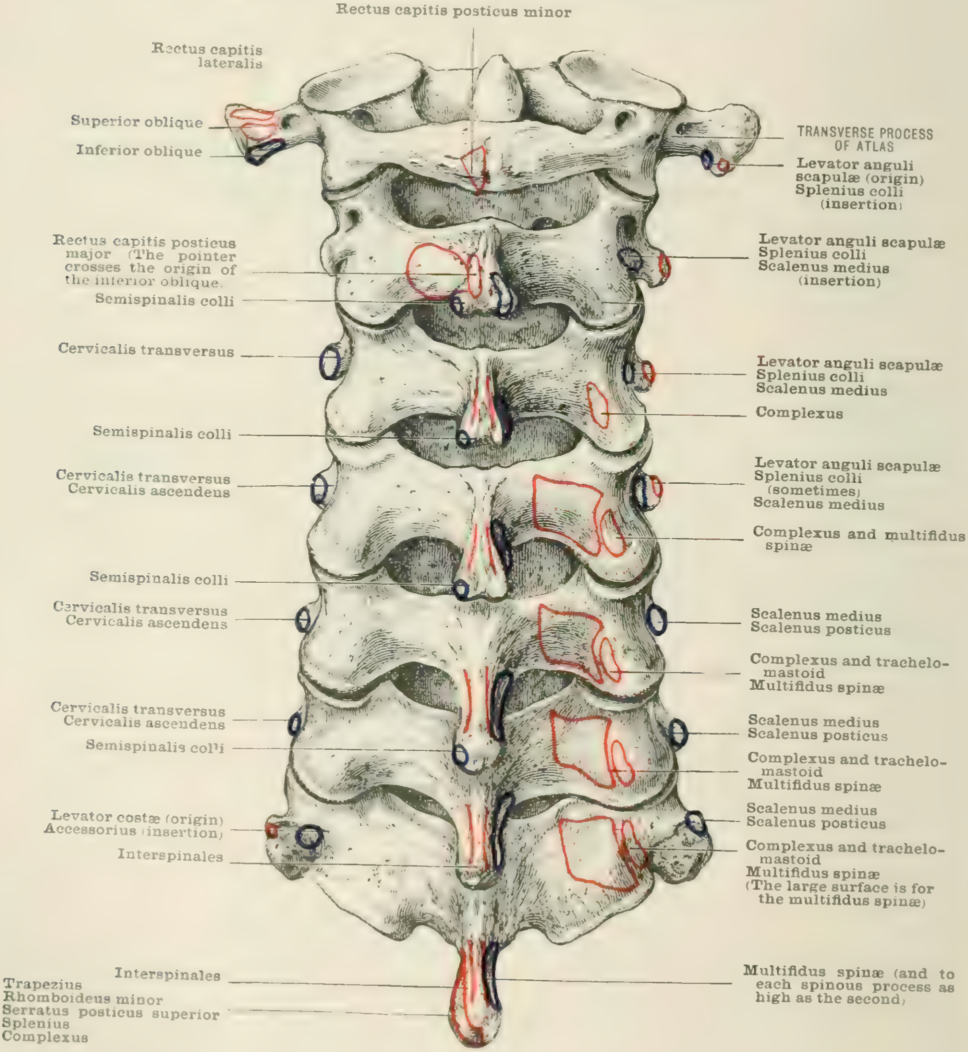
The **spinous process** is stout and strong, deeply concave on its under aspect, and affords firm attachment for muscles, especially those which help to rotate the head.

THE SEVENTH CERVICAL VERTEBRA

This **vertebra** has a longer spinous process than any other cervical vertebra, hence it is sometimes called **vertebra prominens.** The extremity of this process is not bifid, but has two small lateral tubercles which give attachment to the ligamentum nuchæ. The **transverse processes** are of large size; the **costal processes** are very small; and the **costo-transverse** foramina are the smallest of the series or wanting. Very frequently the costal process is segmented off, and constitutes a cervical rib, sometimes of large size.

Occasionally a **demi-facet** exists on each side of the lower border of the centrum for the head of the first rib. When this demi-facet is present, there is usually a well-developed cervical rib.

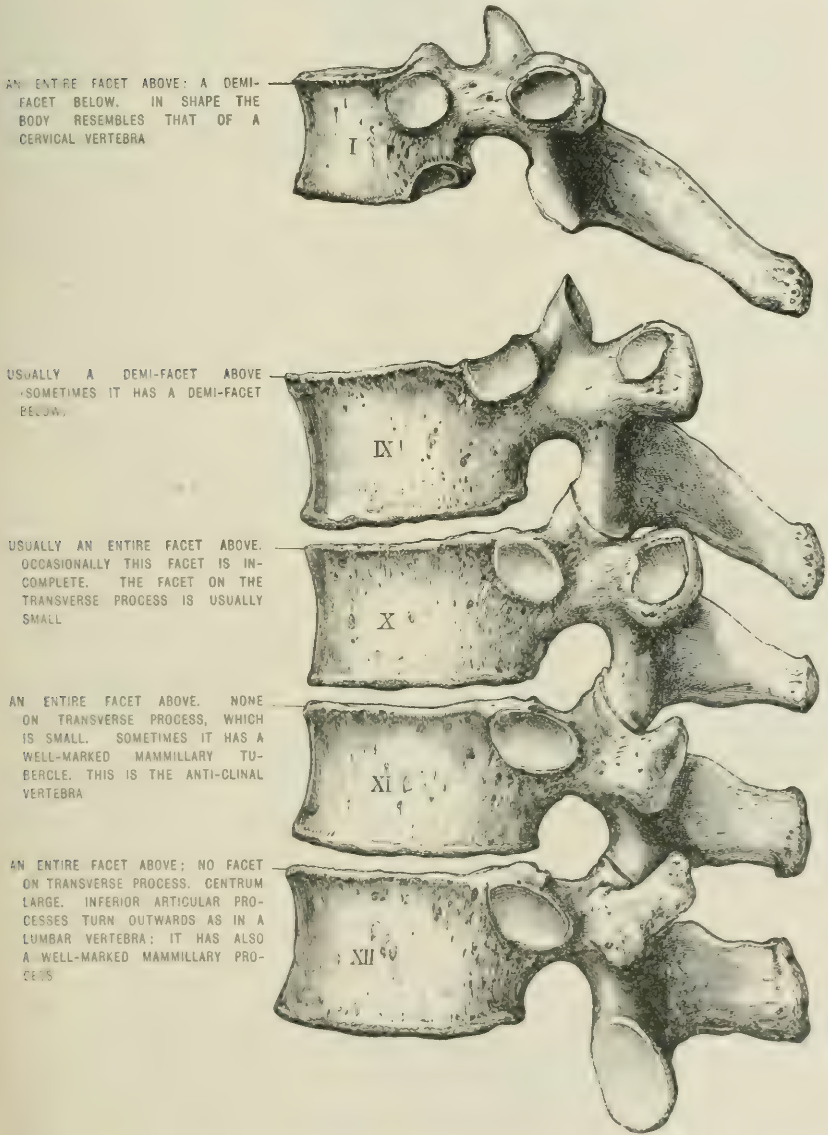
FIG. 11.—THE CERVICAL VERTEBRÆ. (Posterior view.)


Rectus capitis posticus minor
Rectus capitis lateralis
Superior oblique
Inferior oblique
TRANSVERSE PROCESS OF ATLAS
Levator anguli scapulæ (origin) Splenius colli (insertion)
Rectus capitis posticus major (The pointer crosses the origin of the inferior oblique.
Semispinalis colli
Levator anguli scapulæ Splenius colli Scalenus medius (insertion)
Cervicalis transversus
Levator anguli scapulæ Splenius colli Scalenus medius
Complexus
Semispinalis colli
Cervicalis transversus Cervicalis ascendens
Levator anguli scapulæ Splenius colli (sometimes) Scalenus medius
Complexus and multifidus spinæ
Semispinalis colli
Cervicalis transversus Cervicalis ascendens
Scalenus medius Scalenus posticus
Complexus and trachelo-mastoid Multifidus spinæ
Cervicalis transversus Cervicalis ascendens
Semispinalis colli
Scalenus medius Scalenus posticus
Complexus and trachelo-mastoid Multifidus spinæ
Levator costæ (origin) Accessorius (insertion)
Interspinales
Scalenus medius Scalenus posticus
Complexus and trachelo-mastoid Multifidus spinæ (The large surface is for the multifidus spinæ)
Interspinales
Trapezius Rhomboideus minor Serratus posticus superior Splenius Complexus
Multifidus spinæ (and to each spinous process as high as the second)

The cervical vertebræ also exhibit great variation in regard to the extremities of their spinous processes. As a rule among Europeans, the second, third, fourth, and fifth vertebræ possess bifid spines. The sixth and seventh exhibit a tendency to bifurcate, their tips presenting two small lateral tubercles; sometimes the sixth has a bifid spine, and more rarely the seventh presents the same condition. Occasionally all the cervical spines, with the exception of the second, are non-bifid, and even in the axis the bifurcation is not extensive. In the lower races of men the cervical spines are relatively shorter and more stunted than in Europeans generally, and, as a rule, are simple. The only cervical vertebra which presents a bifid spine in all races is the axis; even this may be non-bifid in the Negro, and occasionally in the European. (Owen, Turner, Cunningham.)

The laminæ of the lower cervical vertebræ frequently present over the inferior articular processes distinct tubercles from which fasciculi of the *multifidus spinæ* muscle arise. They are usually confined to the sixth and seventh vertebræ, but are fairly frequent on the fifth, and are occasionally seen on the fourth.

FIG. 12.—PECULIAR THORACIC VERTEBRÆ.


AN ENTIRE FACET ABOVE: A DEMI-FACET BELOW. IN SHAPE THE BODY RESEMBLES THAT OF A CERVICAL VERTEBRA
I
USUALLY A DEMI-FACET ABOVE (SOMETIMES IT HAS A DEMI-FACET BELOW)
IX
USUALLY AN ENTIRE FACET ABOVE. OCCASIONALLY THIS FACET IS INCOMPLETE. THE FACET ON THE TRANSVERSE PROCESS IS USUALLY SMALL
X
AN ENTIRE FACET ABOVE. NONE ON TRANSVERSE PROCESS, WHICH IS SMALL. SOMETIMES IT HAS A WELL-MARKED MAMMILLARY TUBERCLE. THIS IS THE ANTI-CLINAL VERTEBRA
XI
AN ENTIRE FACET ABOVE; NO FACET ON TRANSVERSE PROCESS. CENTRUM LARGE. INFERIOR ARTICULAR PROCESSES TURN OUTWARDS AS IN A LUMBAR VERTEBRA; IT HAS ALSO A WELL-MARKED MAMMILLARY PROCESS
XII

A large number of muscles are attached to the cervical vertebræ.

To the **atlas** :—Rectus capitis anticus minor, rectus capitis posticus minor, rectus capitis lateralis, superior oblique, inferior oblique, longus colli, splenius colli, intertransversales, levator anguli scapulæ.

To the **axis** :— Rectus capitis posticus major, inferior oblique, longus colli, splenius colli, intertransversales, interspinales, levator anguli scapulæ, transversalis cervicis, scalenus medius, semispinalis colli, and multifidus spinæ.

To the **seventh**:—Trapezius, complexus, serratus posticus superior, splenius, rhomboideus minor, multifidus spinæ, semispinalis, eight intertransversales, interspinales, levator costæ, scalenus posticus, accessorius, scalenus medius, trachelomastoid, and the longus colli.

THE THORACIC OR DORSAL VERTEBRÆ

The general characters of the thoracic vertebræ have already been considered in the description of the type vertebra. Their most distinguishing features are the **facets** on the **transverse processes** and sides of the **bodies** for the **tubercles** and **heads of ribs.**

Peculiar thoracic vertebræ.—Several vertebræ in this series differ from the type form. The exceptional are—the **first, ninth, tenth, eleventh,** and **twelfth.**

The **first** has a body resembling a cervical vertebra, the upper surface being concave and lipped laterally; it has two entire facets above for the first pair, and two demi-facets below for the second pair of ribs. The spinous process is thick, strong, almost horizontal, and more prominent than that of the vertebra prominens. Occasionally the transverse process is perforated near its root.

The **ninth** has demi-facets above, and usually none below; when the inferior demi-facets are present, this vertebra is not exceptional.

The **tenth** usually has an entire costal facet at its upper border, on each side, but occasionally only demi-facets. It has no lower demi-facets, and the facets on the transverse processes are usually small.

The **eleventh** has a large body resembling a lumbar vertebra. The rib facets are on the pedicles; they are complete and of large size. The transverse processes are short and have no facets for the tubercles of the eleventh pair of ribs.

In many mammals, the spines of the anterior vertebræ are directed backwards, and those of the posterior directed forwards; in the centre of the column there is usually one spine vertical. This is called the anti-clinal vertebra. It is at this point that the thoracic begin to assume the characters of lumbar vertebræ. In man, the eleventh thoracic is the **anti-clinal** vertebra.

The **twelfth** resembles in general characters the eleventh, but may be distinguished from it in having the inferior articular processes convex and turned outwards as in the lumbar vertebræ. It also resembles a lumbar vertebra by possessing well-marked mammillary and accessory tubercles. These tubercles are occasionally present on the tenth and eleventh vertebræ.

A peculiarity, more frequent in the thoracic and lumbar than in the cervical and sacral regions of the column, is the existence of a half-vertebra. Such specimens have a wedge-shaped half-centrum, to which are attached a lamina, a transverse, superior and inferior articular, and half a spinous process. As a rule, a half-vertebra is ankylosed to the vertebræ above and below.

LUMBAR VERTEBRÆ

The distinguishing features of lumbar vertebræ are their large size; the margins of the centrum are prominent; the **pedicles** are stout and strong; the inferior intervertebral notches are deep, and the **laminæ** are thick and strong. The superior **articular** processes have concave facets directed backwards and inwards, and their posterior borders are surmounted by rounded **mammillary** processes or tubercles. The inferior **articular** processes have facets which look forwards and outwards. The **transverse** processes are long, slender, and each presents near the base, on the posterior aspect, a small **accessory** tubercle. The **spinous** processes are thick, broad, and project horizontally backwards.

The **transverse processes** of the lumbar vertebræ are more complex than they at first appear. Each is compounded of a *transverse* and a *costal process.* *The accessory process represents* *the tip of the partially suppressed transverse process, and the part in front is an undifferentiated rib.* Between the transverse and costal elements some large vascular foramina are usually present, representing the *costo-transverse* foramina of other vertebræ. Occasionally the costal element differentiates, and becomes a well-developed lumbar rib. A glance at the spine will show that the accessory tubercles are in line with the thoracic transverse processes, and the costal elements are in series with the ribs (see also fig. 29).

Fig. 13.—A Lumbar Vertebra. (Side view.)

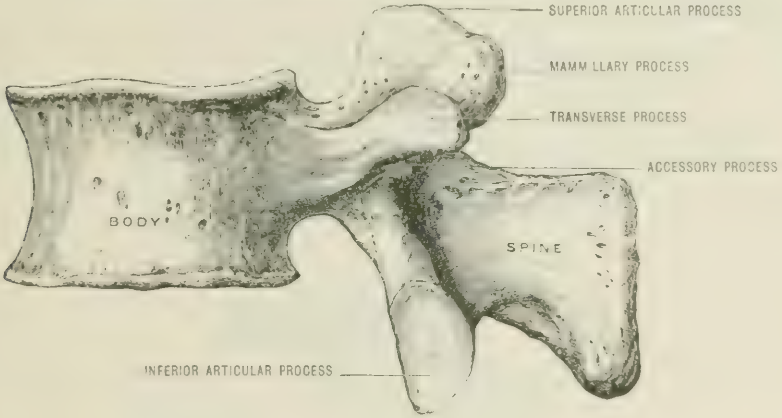
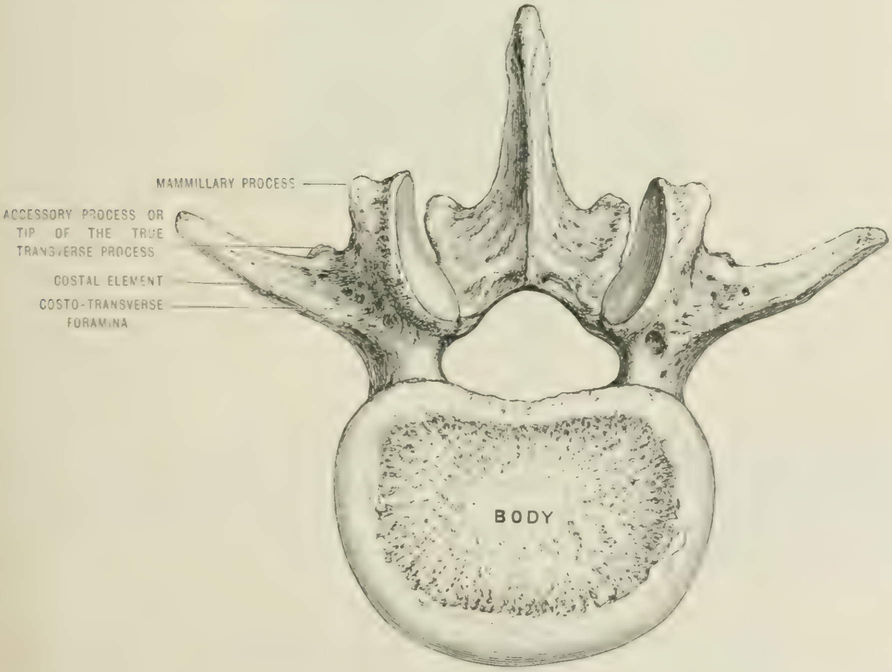

SUPERIOR ARTICULAR PROCESS
MAMMILLARY PROCESS
TRANSVERSE PROCESS
ACCESSORY PROCESS
BODY
SPINE
INFERIOR ARTICULAR PROCESS

Fig. 14.—A Lumbar Vertebra.
(Showing the compound nature of the transverse process. Upper view.)


MAMMILLARY PROCESS
ACCESSORY PROCESS OR TIP OF THE TRUE TRANSVERSE PROCESS
COSTAL ELEMENT
COSTO-TRANSVERSE FORAMINA
BODY

The **fifth** lumbar vertebra has several distinguishing features. The **centrum** is much thicker in front than behind. The **inferior articular** processes are widely separated to articulate with the first sacral vertebra. The **transverse processes** are short and massive, and the pedicles are massive and flattened from above downwards; the **spinous process** is small.

The **pedicles** of this vertebra are liable to a remarkable deviation from the conditions found in other parts of the spine. The peculiarity consists of a complete solution in the continuity of the arch immediately behind the superior articular processes. In such specimens the anterior part consists of the body carrying the pedicles, transverse and superior articular processes ; whilst the posterior segment is composed of the laminæ, spine, and inferior articular processes. The posterior segment of the ring of this vertebra may even consist of two pieces. There is reason to believe that this abnormality of the fifth lumbar vertebra occurs in five per cent. of all subjects examined. Sir William Turner, in his report on the human skeletons in the Challenger Reports, found seven examples among thirty skeletons examined. The skeletons in which this occurred were : a Malay, an Andamanese, a Chinese, two Bushmen, an Esquimau, and a Negro. Turner has also seen it in the skeleton of a Sandwich Islander. A similar condition is occasionally met with either laterally or bilaterally in the thoracic vertebræ.

Fig. 15.—Variation in the Fifth Lumbar Vertebra. (After Turner.)

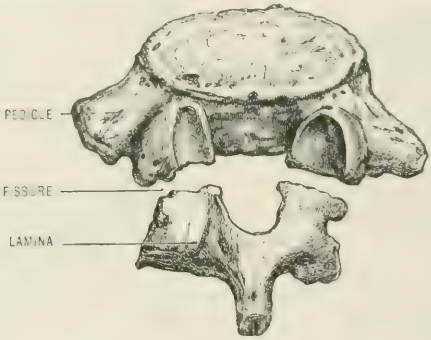
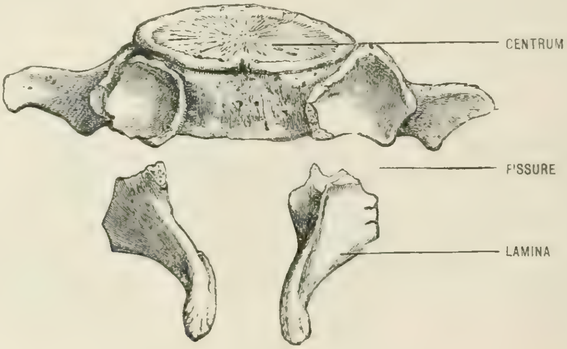


Fig. 16.—A Variation in the Fifth Lumbar Vertebra. (After Turner.)



Each of the five lumbar vertebræ is readily recognisable. The body of the first is deeper behind than in front, the body of the second is of equal depth in front and behind, the bodies of the third, fourth and fifth are deeper in front than behind, but the third has long transverse processes and its lower articular facets are not very widely separated ; the fourth has much shorter transverse processes and the lower articular facets are very wide apart, and the fifth is easily distinguished by the special features already described.

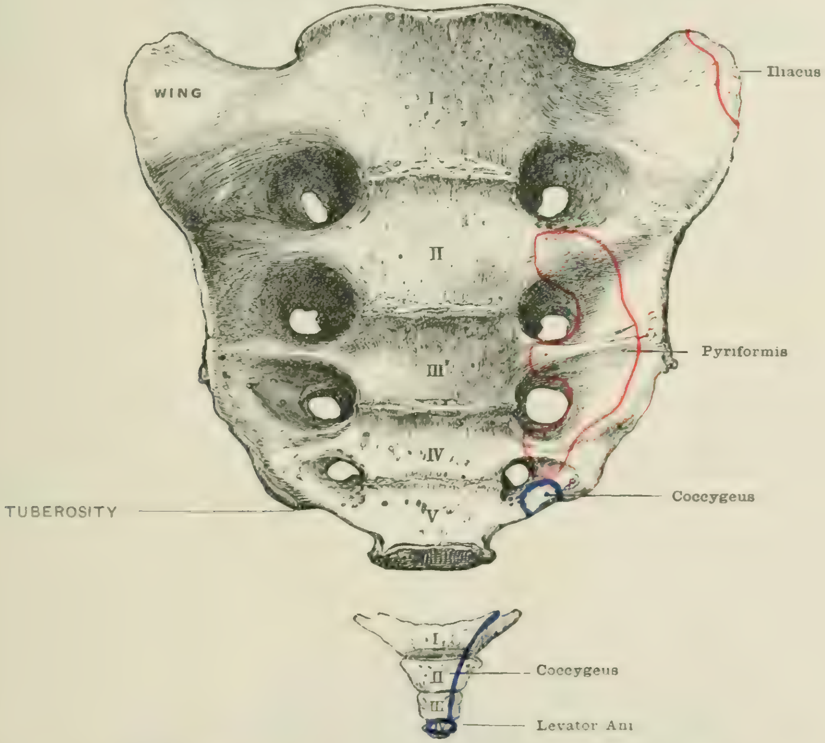
THE SACRAL AND COCCYGEAL VERTEBRÆ

In the adult skeleton, the five vertebræ succeeding the lumbar series are firmly ankylosed to form a single bone, the **sacrum** : the components of the sacrum are termed sacral vertebræ. Beyond the fifth sacral, four, and occasionally five, other rudimentary vertebræ to which the adjective **coccygeal** is applied, are ankylosed in adult life, to form a single piece, the **coccyx**. In advanced life the coccyx unites with the sacrum.

THE SACRUM

This is a large triangular bone, firmly wedged between the innominate bones. It forms the posterior boundary of the true pelvic cavity. The sacrum is curved upon itself with the concavity looking forwards. The upper end of the curve forms, with the body of the fifth lumbar vertebra, an anterior projection known as the **promontory.** The middle portion of the anterior face of the sacrum exhibits four transverse ridges corresponding to the intervertebral spaces. The intervening portions are the bodies of the vertebræ. The upper two sacral vertebræ are almost equal in size to those of the lumbar series, but the three lower rapidly diminish in size from above downwards. The ridges terminate laterally in the **anterior sacral foramina,** four pairs in all, which are the intervertebral foramina of the sacral vertebræ, and transmit the anterior divisions of the first four sacral nerves. The upper two are also traversed by the lateral sacral arteries. The bone immediately outside the foramina corresponds to the **costal processes,** and the portion formed by the second, third, and fourth sacral vertebræ gives origin to the *pyriformis muscle.* The lateral part of the fifth sacral vertebra gives partial insertion to the *coccygeus.*

FIG. 17.—THE SACRUM AND COCCYX. (Anterior view.)



The posterior surface is strongly convex and rough. The middle line is occupied by four tubercles representing the suppressed **spinous processes.** Of these the first is the largest, the second and third may be confluent, and the fourth is often absent. The bone on each side of the spines is formed by the ankylosed **laminæ.** In the fourth sometimes, but always in the fifth, the laminæ fail to meet in the middle line, and this leaves a gap, the **hiatus sacralis.** The median borders of this hiatus are prolonged downwards as rounded processes, the **sacral cornua,** to which the posterior sacro-coccygeal ligaments are attached. External to the laminæ is a second series of small prominences: these are the **articular**

processes. The first pair are large for the last lumbar vertebra, the second and third are small, and the fourth and fifth are inconspicuous.

Immediately external to the articular processes are the **posterior sacral foramina,** four on each side; they are smaller than the anterior, and give exit to the posterior divisions of the first four sacral nerves. External to the foramina there are five eminences on each side, representing the fused **transverse** processes. The first pair are large and conspicuous, and all give attachment to ligaments and muscles; the second form part of the articular surface for the ilium. The furrow formed by the laminæ, and bounded on the median aspect by the spinous, and externally by the articular processes, is known as the **sacral groove,** and it lodges the *multifidus spinæ* muscle.

Fig. 18.—The Sacrum. (Posterior view.)

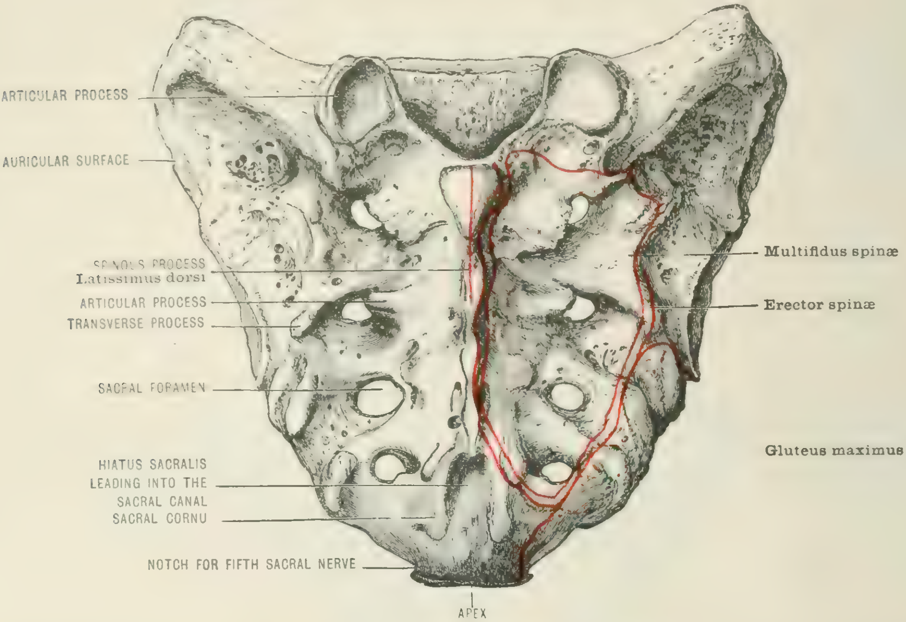
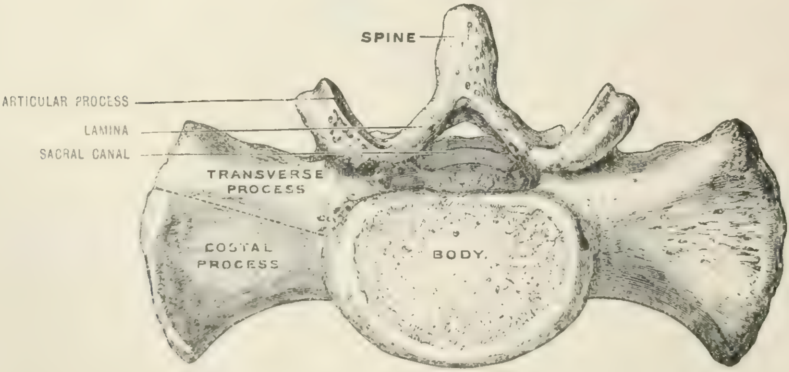

ARTICULAR PROCESS
AURICULAR SURFACE
SPINOUS PROCESS
Latissimus dorsi
ARTICULAR PROCESS
TRANSVERSE PROCESS
SACRAL FORAMEN
HIATUS SACRALIS LEADING INTO THE SACRAL CANAL
SACRAL CORNU
NOTCH FOR FIFTH SACRAL NERVE
APEX
Multifidus spinæ
Erector spinæ
Gluteus maximus

Fig. 19.—Base of Sacrum.


SPINE
ARTICULAR PROCESS
LAMINA
SACRAL CANAL
TRANSVERSE PROCESS
COSTAL PROCESS
BODY.

The upper surface, or **base,** of the sacrum resembles the corresponding aspect of a lumbar vertebra, and its articular processes have well-marked mammillary tubercles. The conjoint transverse and costal processes form on each side a broad surface, the wing or **ala.** From its margin the *iliacus* has a small point of origin.

The **apex** is directed downwards and forwards, and is formed by the inferior aspect of the body of the fifth sacral vertebra; it articulates by means of an intervertebral disc with the coccyx. In advanced life the coccyx and sacrum ankylose at this spot.

The **lateral surface** presents in the upper two-thirds a broad irregular tract called the **auricular process**, which is rough and, in the recent state, covered with fibro-cartilage for union with the ilium. The margins are rough for ligaments. Below the auricular surface each lateral border forms a **tuberosity** and gives attachment to the greater and lesser sacro-sciatic ligaments. Near the extremity it presents a notch which is converted into a foramen by articulation with the coccyx. Through the space thus enclosed, the anterior branch of the fifth sacral nerve issues. Sometimes the foramen is represented by a notch even when the sacrum and coccyx are articulated. The middle of the sacrum is occupied by a continuation of the spinal canal. It is triangular in form at the base, and flattened towards the apex. It lodges the terminal branches of the cauda equina, the filum terminale, and the lower extremity of the dura mater.

The sacrum exhibits sexual and racial differences. In the female it is usually wider, much less curved, and is directed more obliquely backwards, than in the male, and in the lower races the sacrum is relatively longer than in the higher.

Muscles.—The following muscles are attached to the sacrum:—Pyriformis, coccygeus, iliacus, latissimus dorsi, multifidus spinæ, erector spinæ, gluteus maximus; and the occasional muscles, namely, curvator coccygis, extensor coccygis, and the agitator caudæ.

Ligaments.—Anterior and posterior common ligaments of the spine; anterior and posterior sacro-coccygeal; greater and lesser sacro-sciatic, anterior and posterior sacro-iliac, two capsular, ligamenta subflava, and the supraspinous.

THE COCCYX

The coccyx in the adult is made up of four and occasionally five vestigial vertebræ ankylosed to one another. Rarely the number of segments is reduced to three. The first two segments contain, in addition to the body of a vertebra, traces of **articular** and **transverse processes**: the rest are mere nodules of bone, representing centra. The anterior surface gives attachment to the anterior sacro-coccygeal ligament; and near its tip to the *levator ani*; it is in relation with the posterior surface of the second part of the rectum.

The posterior surface is convex, and presents above a laterally projecting process, the rudimentary transverse process of the first segment, and along its margin affords attachment to the *gluteus maximus* muscle.

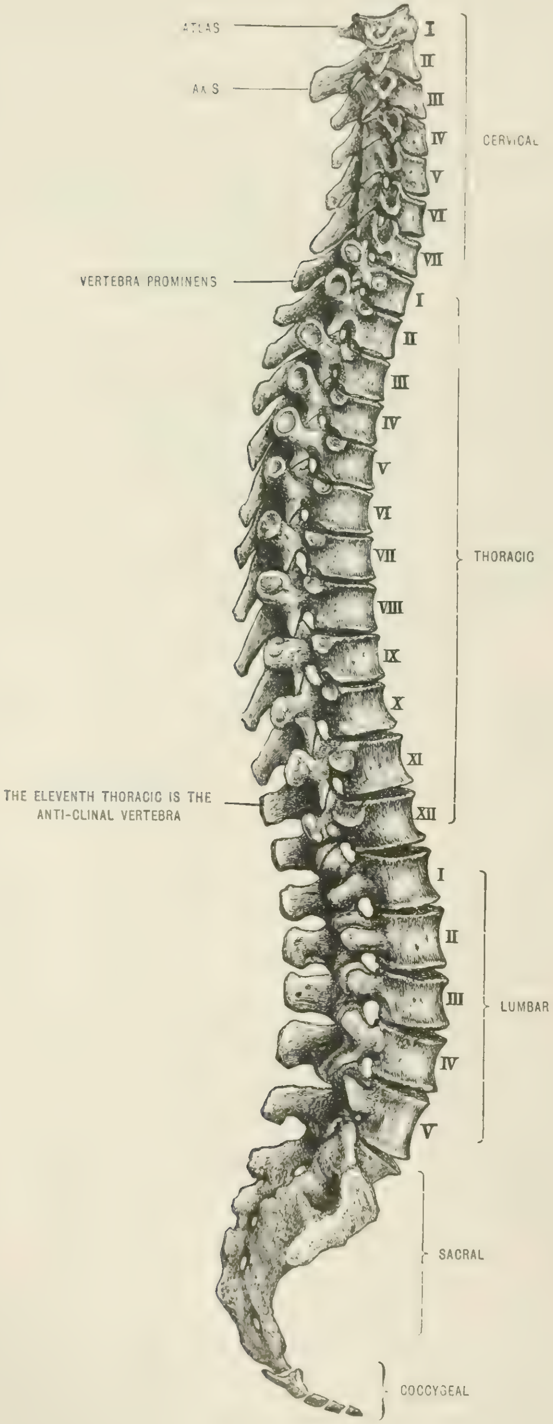
The lateral borders are thin: they receive parts of the greater sacro-sciatic ligaments and of the *coccygeus* muscle. The base has an oval facet for the fifth sacral vertebra, and presents the two long **coccygeal cornua**, formed by the remains of the pedicles and superior articular processes of the first segment, for the posterior sacro-coccygeal ligament. The junction of the coccyx and sacrum completes the foramen of exit for the fifth sacral nerve. In many skeletons the foramen is incomplete externally. The apex is rounded and gives attachment to the *sphincter ani*, and in front to the *levator ani* muscles on each side of the median line.

THE SPINAL COLUMN IN GENERAL

When the various vertebræ are in their relative positions, the whole is termed the **spinal column**. It occupies the median line of the posterior aspect of the trunk. Superiorly, it supports the head; laterally, it gives attachment to the ribs; these in their turn receive the weight of the upper limbs. Inferiorly, the sacrum affords attachment to the innominate bones, by which the weight of the trunk is transmitted to the lower limbs. The spinal column is the axis of the skeleton.

It varies in length in different persons, but on an average it measures, from the atlas to the tip of the coccyx, following the curve, 70 cm. (28″). Of this, the

Fig. 20.—The Spine. (Lateral view.)


ATLAS
AXIS
VERTEBRA PROMINENS
THE ELEVENTH THORACIC IS THE ANTI-CLINAL VERTEBRA
I
II
III
IV
V
VI
VII
CERVICAL
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
THORACIC
I
II
III
IV
V
LUMBAR
SACRAL
COCCYGEAL

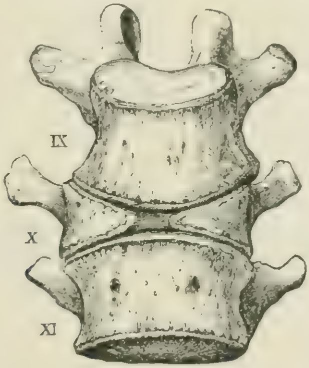
cervical spine measures 12·5 cm. (5″), the thoracic 27·5 cm. (11″), the lumbar 17·5 cm. (7″), and the sacro-coccygeal portion 12·5 cm. (5″).

Viewed in profile, the column presents four **curves**: the first, or **cervical**, is convex anteriorly; the **thoracic** is much larger and longer, with its concavity forward; the **lumbar** curve has its convexity directed anteriorly, and ends somewhat abruptly at the **sacro-vertebral angle**; and to this succeeds the **pelvic curve**, which corresponds to the hollow of the sacrum. In addition to these, the whole column has a slight lateral curve with the convexity to the right, probably due to muscular action.

Viewed from the front, the superimposed bodies present three pyramids. The first is formed by the cervical vertebræ from the second to the seventh. The bodies of the lumbar and thoracic vertebræ form a much longer pyramid. The third is inverted, and formed by the sacrum and coccyx.

Posteriorly, the column presents a median and two lateral rows of processes. The median row is formed by the spinous processes. In the cervical spine, with the exception of the first and the seventh, they are bifid. In the thoracic set they end in rounded tubercles, are long, and for the most part directed obliquely downwards, but in the lower part they become more horizontal until the eleventh is reached. The spine of the eleventh thoracic vertebra is small and almost horizontal; this is the *anti-clinal* vertebra. In the lumbar region the spinous processes are short, stout plates of bone, with their borders set vertically; in the sacrum they are vestigial, and in the coccyx completely suppressed.

FIG. 21.—A DIVIDED THORACIC VERTEBRA. (After Turner.)



The lateral rows are formed by the transverse processes, which are most marked in the thoracic region, where they are rib-bearers. In the cervical spine they are in the same plane as the ribs. The articular processes in the cervical region are in series with the transverse processes of the thoracic vertebræ.

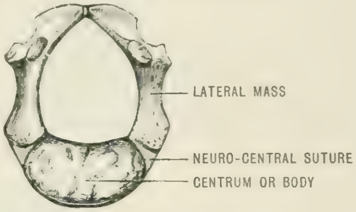
Between the ridges formed by the spinous and transverse processes we recognise the vertebral grooves in which muscles are lodged. The floor of each groove is formed by the laminæ and articular processes, with their mammillary tubercles in the lumbar and lower thoracic regions. Similar tubercles are present on the inferior articular processes of the three lower cervical vertebræ. The intervertebral foramina, oval in shape, are small in the cervical, but gradually increase in size in the thoracic, and are largest in the lumbar region.

Ossification.—The various ossific centers for the vertebræ are deposited in the cartilage which, very early in embryonic life, surrounds the notochord and gradually encloses the spinal cord.

A typical vertebra arises from three primary and numerous secondary centres. The primary centres appear during the sixth week of embryonic life. In the thoracic region the nucleus for the body is first seen, but in the cervical region the lateral centres make their appearance somewhat earlier. The nucleus for the body is deposited around the centre, and quickly becomes bilobed. This bilobed, or dumb-bell, shape is often so pronounced as to give rise to the appearance of two distinct nuclei. Sometimes the nucleus is double, and remains separate throughout life, the vertebra being divided by a vertical fissure (fig. 21). The bifid character of the nucleus of the vertebral body is further emphasised by the occasional occurrence of half-vertebræ. The lateral centres are deposited near the bases of the superior articular processes, and give rise to the pedicles, laminæ, articular processes, and a large part of the transverse and spinous processes.

At birth a vertebra consists of three parts—a body and two lateral masses connected by hyaline cartilage. The line of union of the lateral masses with the bodies is known as the *neuro-central suture* (fig. 22), and this is not obliterated for several years after birth. An examination of a thoracic vertebra at the fifth year will show that a portion of the body of each vertebra is derived from the lateral masses, and that the demi-facets for the rib-heads are situated behind the neuro-central suture, and therefore belong to the pedicles.

FIG. 22.—A VERTEBRA AT BIRTH.

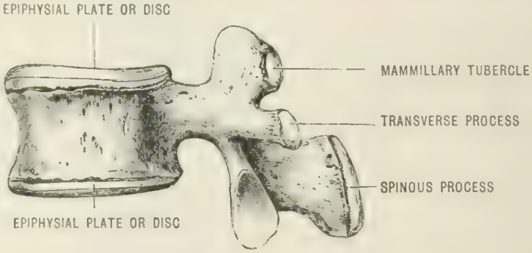


During the early years growth progresses rapidly, and at puberty the secondary centres make their appearance in the cartilaginous tips of the transverse and spinous processes. During the seventeenth year a meniscus of bone forms around the margins of the superior and inferior surfaces of the centra. These are the epiphysial discs; they are thickest at the periphery, and gradually become thin towards the central perforation. By the twenty-fifth year the various secondary nuclei have coalesced with the main bone, and the vertebra is then complete.

In several vertebræ the mode of ossification deviates from the account given above, and requires separate consideration.

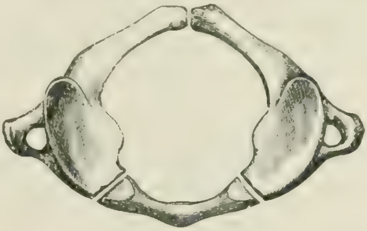
The atlas.—This bone has three primary centres—one for each lateral mass (neural arch) appearing in the sixth week of embryonic life. The third appears a few months after birth for the anterior arch. The lateral portions coalesce posteriorly about the fourth year; the union with the anterior nucleus is delayed until the sixth year. An additional centre occasionally appears for the posterior segment.

FIG. 23.—LUMBAR VERTEBRA AT THE EIGHTEENTH YEAR WITH SECONDARY CENTRES.



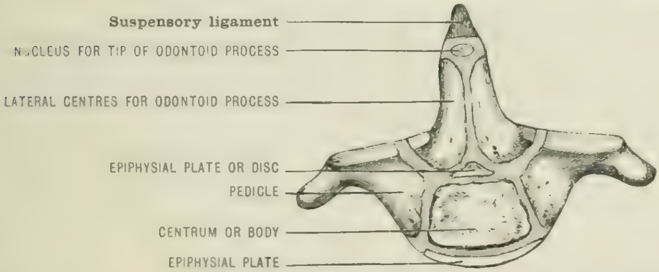
The axis.—This is the most exceptional of all the vertebræ. It has the usual three primary nuclei—one for the body, and one on each side for the neural arch. The centre for the body appears in the embryo about the fifth month, and a few weeks later, two laterally disposed nuclei are seen for the base of the odontoid process; these fuse together in the middle line, and by the third year ankylose peripherally to the centrum of the axis. The line of union between the body of the axis and the odontoid process is indicated even in advanced life by a persistent lenticular-shaped cartilage. During the second year a nucleus appears at the tip of the odontoid process; it joins the main mass at the fourth year. An epiphysial meniscus for the inferior and superior surfaces of the centrum of the axis appears about the seventeenth year. As a rule, the superior meniscus is represented by a few earthy granules.

FIG. 24.—IMMATURE ATLAS. (Third year.)



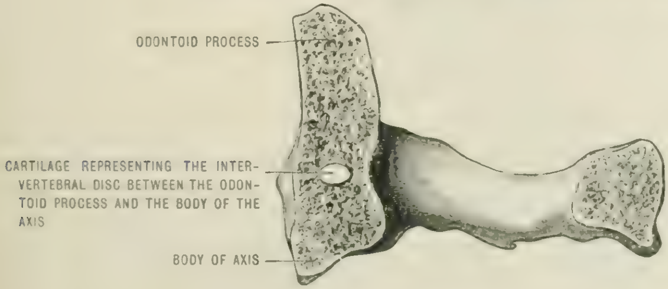
The sixth and seventh vertebræ.—In the cervical vertebræ the pedicles, or anterior extremities of the neural arches, take a much larger share in forming the centrum than is the case with the remaining vertebræ. The sixth, seventh, and possibly other cervical vertebræ present an additional centre on each side of the neural arch for the costal process; it appears before birth. The costal processes of the seventh cervical not infrequently fail to ankylose with the vertebra; when this is the case, the processes become cervical ribs. Sometimes these ribs are of large size.

FIG. 25.—DEVELOPMENT OF THE AXIS.


Suspensory ligament
NUCLEUS FOR TIP OF ODONTOID PROCESS
LATERAL CENTRES FOR ODONTOID PROCESS
EPIPHYSIAL PLATE OR DISC
PEDICLE
CENTRUM OR BODY
EPIPHYSIAL PLATE

The lumbar vertebræ.—In the lumbar vertebræ, two additional centres make their appearance, about puberty, namely, for the mammillary tubercles on the posterior aspect of each superior articular process.

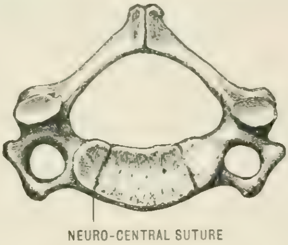
FIG. 26.—THE AXIS (FROM AN ADULT) IN SECTION.


ODONTOID PROCESS
CARTILAGE REPRESENTING THE INTERVERTEBRAL DISC BETWEEN THE ODONTOID PROCESS AND THE BODY OF THE AXIS
BODY OF AXIS

The *fifth* lumbar occasionally differs in the mode of ossification of its arch; in many skeletons this arch is derived from four nuclei. There is a nucleus on each side for the pedicle, the transverse process, and the superior articular process; and one on each side for the lamina, inferior articular process, and the lateral half of the spinous process (fig. 28). The pedicles may fail to join the laminæ; more rarely the laminæ fail to fuse (fig. 16).

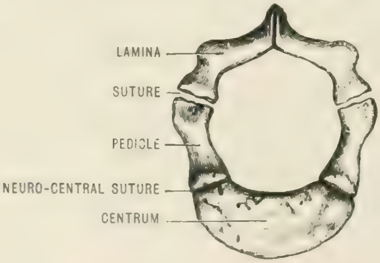
The sacral vertebræ.—In addition to the three primary vertebral centres, the three upper sacral vertebræ have each an extra pair corresponding to the costal processes of the seventh cervical vertebra; they appear at the seventh month. These processes are very large in the first sacral, smaller in the second, and very small in the third. Although the various primary centres of the sacral vertebræ appear much later than in other regions of the column, yet they are all visible at birth. The centrum of each sacral vertebra develops a superior and an inferior epiphysial meniscus, and eventually the five vertebræ fuse to form a single bone, the sacrum. Even in advanced life the intervertebral discs between the sacral vertebræ persist in the centre of the bone. The ear-shaped lateral articular facet on the side of the sacrum arises from two additional centres on each side, about the eighteenth year. The total number of ossific centres for the sacrum is thirty-five.

Fig. 27.—An Immature Cervical Vertebra.



The coccygeal vertebræ.—These are cartilaginous at birth. A few months later the first segment ossifies. The remaining three ossify from above downwards before the twentieth year. By the twentieth year the first three have usually coalesced. The fourth fuses with them later, and the coccyx ankyloses with the sacrum, as a rule, late in life.

Fig. 28.—Ossification of the Fifth Lumbar Vertebra.



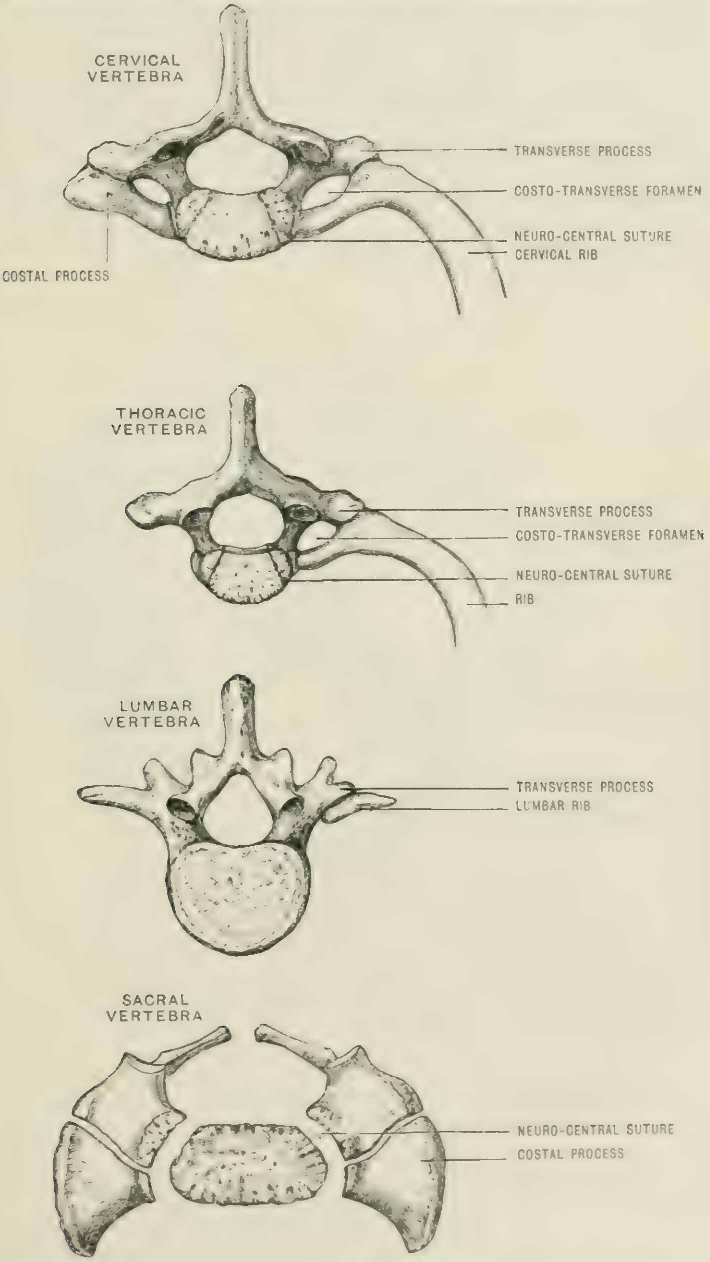
The Serial Morphology of the Vertebræ

Although at first sight many of the vertebræ exhibit peculiarities, nevertheless a study of the mode by which they develop, and their variations, indicates the serial homology of the constituent parts of the vertebræ in each region of the column.

The *centrum*, or body of the vertebra, is that part which immediately surrounds the notochord. This part is present in all the vertebræ of man, but the centrum of the atlas is dissociated from its neural arch, and ankylosed to the body of the axis. The reasons for regarding the odontoid process as the body of the atlas are these: In the embryo the notochord passes through it on its way to the base of the cranium. Between the odontoid process and the body of the axis, there is a swelling of the notochord in the early embryo as in other intervertebral regions. This swelling is later indicated by a small intervertebral disc hidden in the bone, but persistent even in old age. The odontoid process arises from primary centres, and in chelonians it remains as a separate ossicle throughout life; in Ornithorhynchus it remains distinct for a long time, and it has been found separate even in an adult man. Lastly, in man and many mammals, an epiphysial plate develops between it and the true body of the axis.

The anterior segment of the atlas is most probably an enlarged *hypapophysis* or subvertebral wedge-bone, which, in lizards, exists on the ventral aspect of the column between individual centra. Similar ossicles occur in the lumbar region of the mole. (Froriep regards this segment as the ossified primitive ventral arch which precedes the body and which disappears after the formation of the latter in all the other vertebræ.)

FIG. 29.—MORPHOLOGY OF THE TRANSVERSE AND ARTICULAR PROCESSES.


CERVICAL VERTEBRA
TRANSVERSE PROCESS
COSTO-TRANSVERSE FORAMEN
NEURO-CENTRAL SUTURE
CERVICAL RIB
COSTAL PROCESS
THORACIC VERTEBRA
TRANSVERSE PROCESS
COSTO-TRANSVERSE FORAMEN
NEURO-CENTRAL SUTURE
RIB
LUMBAR VERTEBRA
TRANSVERSE PROCESS
LUMBAR RIB
SACRAL VERTEBRA
NEURO-CENTRAL SUTURE
COSTAL PROCESS

The *neural arches* and *spinous processes* are easily recognised throughout the various parts of the column in which complete vertebræ are present.

The *articular processes* are of no morphological value, and do not require consideration here.

The *transverse processes* offer more difficulty. They present themselves in the simplest form in the thoracic series. Here they articulate with the tubercles of the ribs. The transverse process and the neck of the rib enclose an arterial foramen, the costo-transverse. In the cervical region this rib, or costal element, and the transverse process are fused together, but the conjoint process thus formed is pierced by the costo-transverse foramen. The compound nature of the process is indicated by the fact that the anterior or costal processes in the lower cervical vertebræ arise from additional centres and occasionally retain their independence as cervical ribs. These processes in Sauropsida (birds and reptiles) are represented by free ribs. In the lumbar region, the compound nature of the transverse process is further marked. The true transverse process is greatly suppressed, and its extremity is indicated by the accessory tubercle. Anterior to this in the adult vertebra a group of holes represents the costo-transverse foramen, and the portion in front of this is the costal element. Occasionally it will persist as an independent ossicle, the lumbar rib.

In the sacral series the costal elements are peculiarly modified in the first three vertebræ to form piers of bone for articulation with the ilium. The costo-transverse foramina are completely obscured. In rare instances the first sacral vertebra will articulate with the ilium on one side, but remain free on the other. Under such conditions the free process exactly resembles the elongated transverse process of a lumbar vertebra. The first three sacral vertebræ which develop a costal process (rib) for articulation with the ilium are *true sacral* vertebræ. Those ankylosed below these are *pseudo-sacral.* A glance at fig. 29 will show the homology of the various parts of a vertebra from the cervical, thoracic, lumbar and sacral regions.

The mammillary processes are vestiges of the greatly elongated articular processes of such mammals as the dog, armadillo, &c.

THE BONES OF THE SKULL

The skeleton of the head is called the **skull**: it contains, in the adult, twenty-nine separate bones. For descriptive purposes they are divided in two groups: those of the **skull proper,** and the **appendicular elements.**

I. The Skull

- (*a*) **Basilar Bones**
  - Occipital.
  - Sphenoid.
  - Temporals.
- (*b*) **Roof Bones**
  - Parietals.
  - Frontal.
  - Epipterics.
- (*c*) **Nasal Region**
  - Ethmoid.
  - Sphenoidal turbinals.
  - Turbinals.
  - Lachrymals.
  - Vomer.
  - Nasals.
- (*d*) **Facial Bones**
  - Maxillæ.
  - Palatines.
  - Malars.

II. Appendicular Elements

Mandible.
Malleus.
Incus.
Stapes.
Hyoid.
Styloid.
Internal pterygoid.

The *epipterics* are not always separate in the adult skull: the *styloid* ankyloses with the temporal, and the *internal pterygoid* with the sphenoid.

THE OCCIPITAL

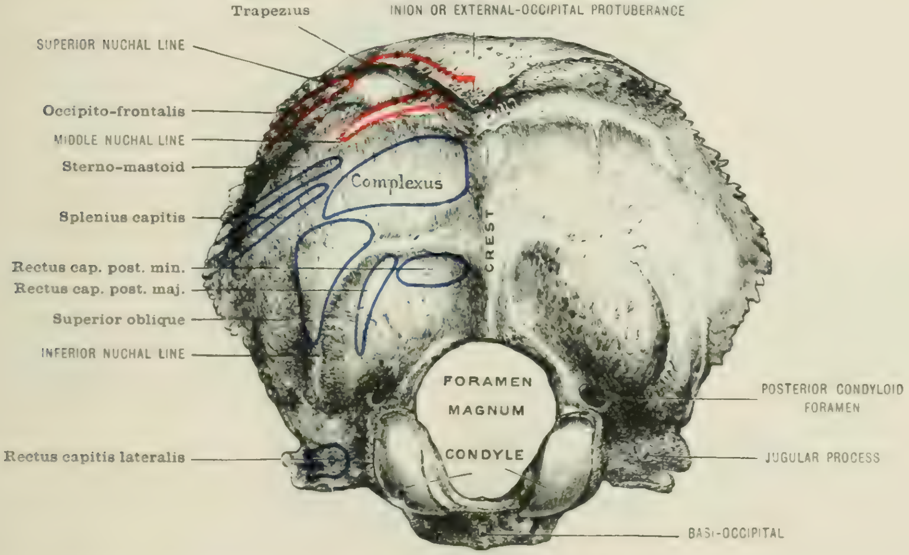
This bone forms the back and a portion of the base of the skull. At birth it consists of four distinct parts disposed around the foramen magnum (fig. 34). These, in the adult, fuse together and form a single bone, which ankyloses with the sphenoid. The four parts of the occipital are—the **squamo-occipital,** two **ex-occipitals,** and a **basi-occipital.** The lines of union of these parts are easily distinguished even in the oldest skull.

The **squamo-occipital** is saucer-shaped, deeply concave on its cerebral, but convex on its external aspect. It consists of two parts which have different modes of origin. The posterior surface is divided by a ridge, the **superior nuchal** line, into a lozenge-shaped superior portion with a smooth surface and an inferior rough portion. The upper is the **interparietal,** and the lower the **supra-occipital** segment. The interparietal portion not infrequently persists as an independent ossicle (fig. 35).

The supra-occipital is divided into two lateral halves by a median vertical ridge—the **external occipital crest**—which ascends from the middle of the posterior margin of the foramen magnum, to terminate at the **external occipital protuberance,** or **inion,** near the middle of the squamo-occipital. The protuberance and crest give attachment to the ligamentum nuchæ.

Each lateral half of the supra-occipital presents three pairs of transverse ridges, the **nuchal lines.** Of these the **superior** is usually the least conspicuous, but most curved; frequently it is absent; beginning at the external occipital protuberance, it curves outwards to the lateral angle. It affords attachment to the epicranial aponeurosis and to few fibres of the *occipito-frontalis* muscle.

FIG. 30.—THE OCCIPITAL. (External view.)


Trapezius
INION OR EXTERNAL-OCCIPITAL PROTUBERANCE
SUPERIOR NUCHAL LINE
Occipito-frontalis
MIDDLE NUCHAL LINE
Sterno-mastoid
Complexus
Splenius capitis
CREST
Rectus cap. post. min.
Rectus cap. post. maj.
Superior oblique
INFERIOR NUCHAL LINE
FORAMEN MAGNUM
POSTERIOR CONDYLOID FORAMEN
Rectus capitis lateralis
CONDYLE
JUGULAR PROCESS
BASI-OCCIPITAL

The **middle nuchal** line (sometimes called the superior curved line) commences a little distance below the protuberance, and curves outwards to end below the lateral angle. In some cases the superior and middle nuchal lines are confluent in their outer thirds, and form a prominent ridge for the insertion of the *sterno-mastoid* and *splenius capitis* muscles. When these muscles are well developed, there is a fairly wide interval between the lines.

The **inferior nuchal line** begins near the middle of the crest and curves downwards to the jugular process.

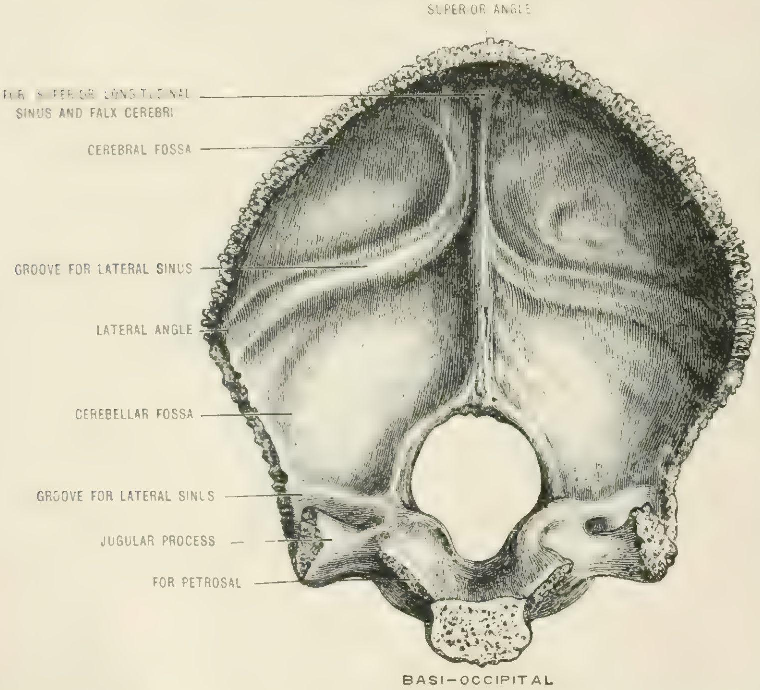
Of the spaces deliminated by these lines, that between the superior and middle is occupied by the *trapezius*, and frequently by the *sterno-mastoid* and *splenius capitis* muscles. The space between the middle and inferior receives the *complexus* and *superior oblique*, and the space between the inferior line and the foramen magnum is occupied by the *rectus capitis posticus minor*, and the *rectus capitis posticus major* muscles.

The **cerebral surface** is deeply concave, and divided by **crucial ridges** into four fossæ, of which the upper two accommodate the occipital lobes of the cerebrum, the lower pair the cerebellar hemispheres. The ridges intersect one another, and at the point where they cross, an eminence, the **internal occipital protuber-**

ance, is seen. The vertical ridge runs upwards to the superior angle of the bone and furnishes attachment for the falx cerebri; the portion of the ridge below the protuberance, the **internal occipital crest,** is for the falx cerebelli. As it approaches the foramen magnum this ridge divides, becoming lost upon its margins. The angle of divergence is sometimes occupied by a shallow fossa for the extremity of the vermiform process of the cerebellum, and is called the *vermiform fossa.* The horizontal ridge is deeply grooved; to the edges of the groove the tentorium cerebelli is attached; the grooves lodge the greater part of the lateral sinuses. To one side of the internal occipital protuberance, usually the right, the furrow for the sinus is deeper and frequently forms a circular fossa which receives the *torcular.* This fossa is sometimes exactly in the middle line.

The squamo-occipital has three angles and four borders. The **superior angle** fits into the space formed by the union of the two parietals. The **lateral angles** mark the external limits of the middle nuchal lines, and occupy the angle formed by the parietal and mastoid portion of the petrosal on each side. The ridge between the superior and lateral angles is the **superior border**; it is serrated deeply, and articulates with the posterior border of the parietal to form the lambdoid suture. The **inferior border** extends from the lateral angle to the **jugular process**; it articulates with the mastoid portion of the petrosal.

FIG. 31.—OCCIPITAL BONE, CEREBRAL SURFACE.



The **ex-occipitals** form the lateral boundaries of the foramen magnum. The lateral surface of each ex-occipital is extended outwards to form a quadrilateral buttress of bone, the **jugular process.** This has an outer rough surface for articulation with the jugular surface of the petrosal. Its anterior border is deeply notched to form the posterior boundary of the jugular foramen, and the notch is directly continuous with a groove on the upper surface which lodges the termination of the lateral sinus. Its under surface gives attachment to the *rectus capitis lateralis* and the oblique occipito-atlantal ligament. The pneumatic mastoid cells occasionally extend into this process. Rarely a process of bone projects from its under surface and represents the *paroccipital process* present in many mammals. The rest of the ex-occipitals enter into the formation of the *condyles,* and will be separately described.

The **basi-occipital** is a quadrilateral plate of bone. Its superior surface is concave for the medulla oblongata. Inferiorly it is rough, and presents the **pharyngeal tubercle,** to which the median portion of the fibrous bag of the pharynx is attached. In front of the tubercle near the anterior end of the bone there is often a shallow fossa, which originally received the primitive anterior extremity of the foregut. The *rectus capitis anticus major* and *minor* muscles are inserted into this surface. Anteriorly the basi-occipital is, in the adult, ankylosed to the basisphenoid. Posteriorly it has a smooth, rounded, narrow, concave border forming the anterior boundary of the foramen magnum.

FIG. 32.—CEREBRAL SURFACE OF THE OCCIPITAL, SHOWING AN OCCASIONAL DISPOSITION OF THE CHANNELS.

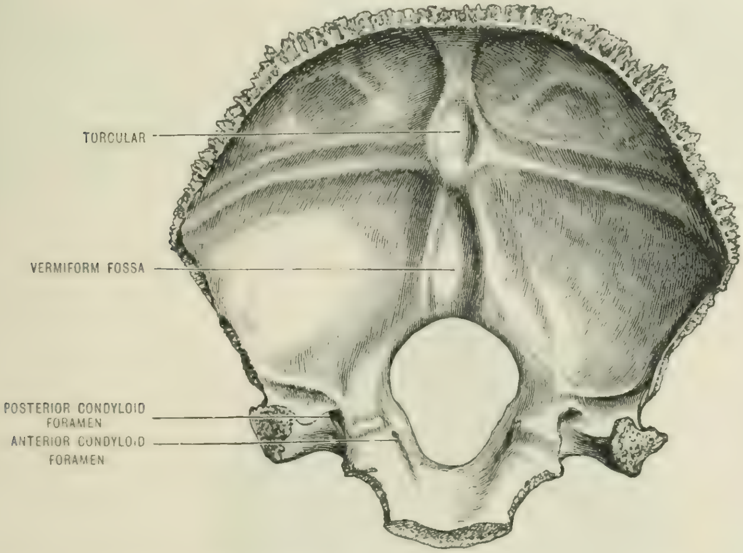
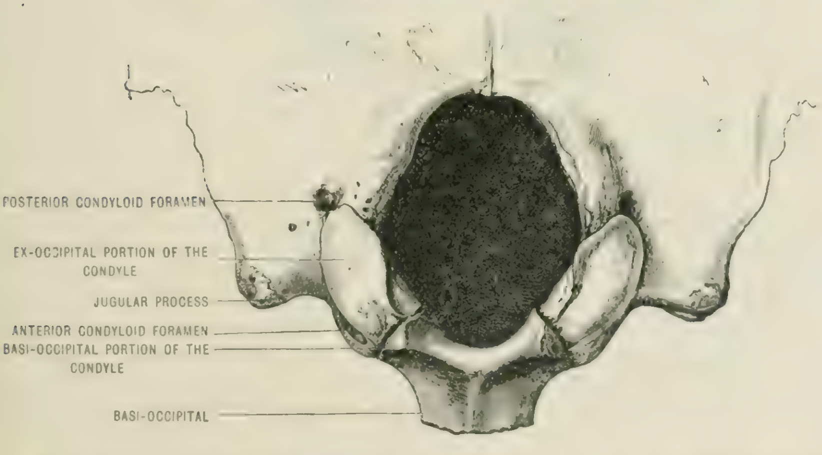

TORCULAR
VERMIFORM FOSSA
POSTERIOR CONDYLOID FORAMEN
ANTERIOR CONDYLOID FORAMEN

FIG. 33.—THE FORAMEN MAGNUM AT THE SIXTH YEAR.

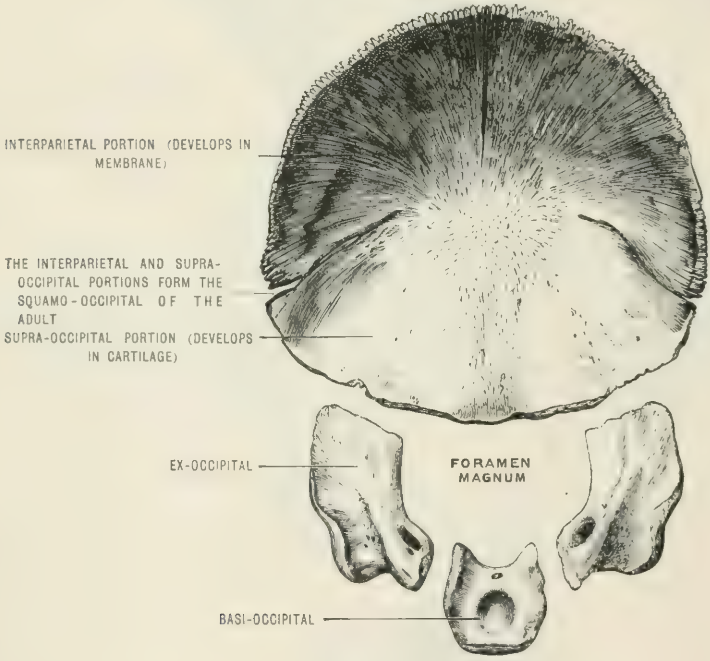

POSTERIOR CONDYLOID FORAMEN
EX-OCCIPITAL PORTION OF THE CONDYLE
JUGULAR PROCESS
ANTERIOR CONDYLOID FORAMEN
BASI-OCCIPITAL PORTION OF THE CONDYLE
BASI-OCCIPITAL

The extremities of this border enlarge to join the ex-occipitals, and form the anterior extremities of the condyles. The lateral borders are rough below, and articulate with the inferior borders of the petrosals. Above they are grooved for the **inferior petrosal sinus.**

The **foramen magnum** is oval in shape, with its major axis in the long axis of the skull. In front of the middle it is encroached upon by the condyles. It is bounded posteriorly by the supra-occipital, anteriorly by the basi-occipital, and laterally by the ex-occipitals. Sometimes a facet exists at the anterior margin for articulation with the odontoid process. This is the *tertiary occipital condyle*. The margin of the foramen gives attachment behind the condyles to the posterior occipito-atlantal ligament.

The **condyles** are two oval processes of bone, with smooth articular surfaces, covered in the recent state with cartilage. They are received into the superior articular cups of the atlas. The condyles converge anteriorly but diverge posteriorly. Their margins give attachment to capsular ligaments, and a prominent tubercle in the middle of the median border of each condyle is for the check ligament. A foramen, the **anterior condyloid**, traverses the upper part of each condyle; it transmits the hypoglossal nerve, and a twig of the ascending pharyngeal artery with its venæ comites; frequently this foramen is divided by a delicate spicule of bone. Posterior to each condyle is a depression, the *posterior condyloid fossa*, which receives the hinder edge of the articular cavity of the atlas when the head is extended; the floor of this depression is occasionally perforated by the *posterior condyloid foramen*, which transmits a vein from the lateral sinus.

Fig. 34.—The Occipital at Birth. (Anterior view.)


INTERPARIETAL PORTION (DEVELOPS IN MEMBRANE)
THE INTERPARIETAL AND SUPRA-OCCIPITAL PORTIONS FORM THE SQUAMO-OCCIPITAL OF THE ADULT
SUPRA-OCCIPITAL PORTION (DEVELOPS IN CARTILAGE)
EX-OCCIPITAL
FORAMEN MAGNUM
BASI-OCCIPITAL

Articulations.—The occipital bone is connected by suture with the two parietals, the two temporals, and the sphenoid; by means of the condyles it articulates with the atlas; and under the exceptional condition of a tertiary occipital condyle, with the odontoid process of the axis.

Muscles.—Attached to the occipital bone:—

Occipito-frontalis.
Trapezius.
Sterno-cleido-mastoid.
Complexus.
Splenius capitis.
Superior oblique.
Rectus capitis anticus major.
Rectus capitis anticus minor.
Rectus capitis posticus major.
Rectus capitis posticus minor.
Rectus capitis lateralis.
Azygos pharyngei (when present).

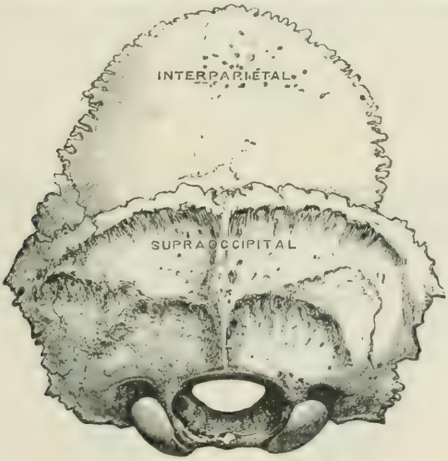
Ligaments :—

Ligamentum nuchæ.
Capsular.
Posterior occipito-atlantal.
Anterior occipito-atlantal.
Oblique occipito-atlantal.
Suspensory ligament.
Check ligaments.
Vertical slip of the crucial.
Posterior common ligament of spine.
Anterior common ligament of spine.
The fibrous bag of the pharynx.

Blood-supply.—The occipital bone receives branches from the occipital, posterior auricular, middle meningeal, vertebral and ascending pharyngeal arteries.

Development.—The interparietal portion of the occipital is a membrane-bone, and arises usually by two and occasionally by four centres about the twelfth week; these nuclei rapidly become confluent and fuse with the supra-occipital portion about the fifteenth week. Occasionally this fusion fails. The centres for the rest of the bone are deposited in cartilage. The nucleus for the basi-occipital appears in the tenth week, and is quickly followed by a nucleus for each ex-occipital; the supra-occipital ossifies from two laterally disposed nuclei, which quickly coalesce and fuse with the interparietal portion near the situation of the future occipital protuberance. For many weeks two deep lateral fissures separate the interparietal and supra-occipital portions, and a membranous space, extending from the centre of the squamo-occipital to the foramen magnum, partially separates the lateral portions of the supra-occipital. This space becomes occupied by a spicule of bone, and is of interest, because through it hernia of the brain and its membranes, known as occipital meningocele or encephalocele, occurs.

Fig. 35.—The Occipital with a Separate Interparietal.



At birth the occipital consists of four parts: the squamo-occipital, two ex-occipitals, and the basi-occipital, united by strips of cartilage. The ex-occipitals and squamo-occipital fuse together about the fifth year, and unite with the basi-occipital before the seventh year. The posterior two-thirds of each occipital condyle belongs to the ex-occipitals, and the anterior third to the basi-occipital (fig. 33).

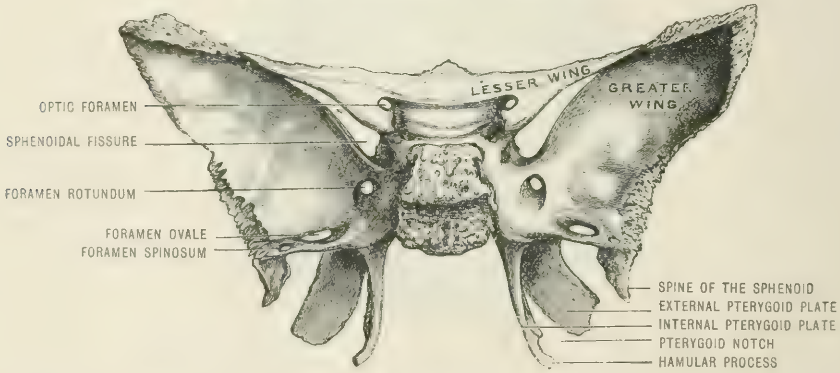
Not infrequently the interparietal portion remains separate throughout life, and may even be represented by numerous detached ossicles or Wormian bones. By the twenty-fifth year the basi-occipital is firmly ankylosed to the sphenoid.

THE SPHENOID

The sphenoid forms a large part of the base of the skull in the region of the anterior and middle fossæ. It is very irregular in shape, and is best described as consisting of a body, two pairs of wings, and two pairs of processes.

The **body** is irregularly cuboidal in shape. The **superior surface** presents the following points for examination. In front, there is a prominent spine, which is received between the diverging alæ of the crista galli, and is known as the **ethmoidal spine.** The surface behind this is smooth, and is formed by extensions of the lesser or orbital wings; it frequently presents two parallel longitudinal grooves for the olfactory bulbs. This smooth surface is terminated by a ridge, the **limbus,** behind which is the **optic groove** lodging the optic chiasma, and leads on each side into the **optic foramen.** The groove is bounded posteriorly by the **olivary eminence,** a ridge of bone indicating the line of union of the **pre-** and **post-sphenoid.** Behind this ridge the bone presents a deep hollow, the **pituitary fossa,** in which the pituitary body is lodged. The floor of this fossa presents numerous foramina for blood-vessels, and at birth the superior orifice of a narrow passage termed the **cranio-pharyngeal canal.** The pituitary fossa presents on each side, slightly posterior to the olivary eminence, a tubercle of variable size, the **middle clinoid process.** This is occasionally prolonged to meet the **anterior clinoid process** on the orbital wing. The posterior boundary is formed by a quadrilateral plate of bone, the **dorsum ephippii.** The superior angles of this plate are surmounted by the **posterior clinoid processes,** which give attachment to the tentorium cerebelli. A little below the clinoid process, on each side of the dorsum ephippii, there is a deep notch, converted into a foramen by the dura mater, for the passage of the sixth cranial nerve. The dorsum is slightly concave posteriorly, and supports the basilar artery and the pons.

FIG. 36.—THE SPHENOID. (Viewed from above.)



The **inferior surface** of the body has a prominent median ridge, the **rostrum,** which is received between the alæ of the vomer. The rest of the surface is rough, and covered by the mucous membrane belonging to the roof of the pharynx.

The **anterior surface** presents in the middle line a vertical ridge of bone, the **sphenoidal crest,** which articulates with the perpendicular plate of the ethmoid. On each side of the crest is a groove which forms part of the roof of the nose; it is bounded externally by a more or less circular orifice which leads into the **sphenoidal sinuses.** Still more externally is a rough area for articulation with the lateral mass of the ethmoid. These sinuses are irregularly shaped, unsymmetrical cavities, separated from one another by a thin vertical septum; in adult bones they may extend into the roots of the pterygoid processes, and even into the base of the occipital bone. The sinuses communicate with the nasal fossa of their respective sides. The lateral margins of the anterior surface are serrated for articulation with the posterior border of the os planum on each side of the ethmoid. The superior margin articulates with the cribriform plate of the ethmoid.

The **posterior surface** or basi-sphenoid is, in the adult, ankylosed to the basi-occipital. The two bones are separated by a disc of hyaline cartilage until the eighteenth year; by the twenty-fifth year ankylosis is complete.

The **lateral surface** enters into the formation of the posterior part of the inner wall of the orbit; it forms the inner boundary of the sphenoidal fissure, and more posteriorly is grooved for the internal carotid artery and cavernous sinus.

The process of bone over which this artery turns is the **lingula**; it constitutes a flying buttress for the support of the greater wings.

The **lesser** or **orbital wings** (orbito-sphenoids) are thin, triangular, horizontal plates of bone resting upon that portion of the sphenoid anterior to the olivary ridge (pre-sphenoid). The superior surface of each wing is smooth and slightly concave, and forms the posterior part of the anterior fossa of the skull; the under surfaces constitute a portion of the roof of each orbit, and bound superiorly the **sphenoidal fissures.** The anterior border is serrated for articulation with the horizontal plate of the frontal bone. The posterior border, smooth and rounded, is received into the Sylvian fissure of the cerebrum. The inner extremity is prolonged to form the **anterior clinoid process** to which the tentorium cerebelli is attached. Each lesser wing is connected to the body of the bone by two processes or roots; of these, the upper is thin and flat, the lower one is thicker, and presents near its junction with the body a small tubercle for the attachment of the common tendon of three ocular muscles. The opening between the roots is the **optic foramen,** and transmits the optic nerve and ophthalmic artery.

Fig. 37.—The Left Half of the Sphenoid.

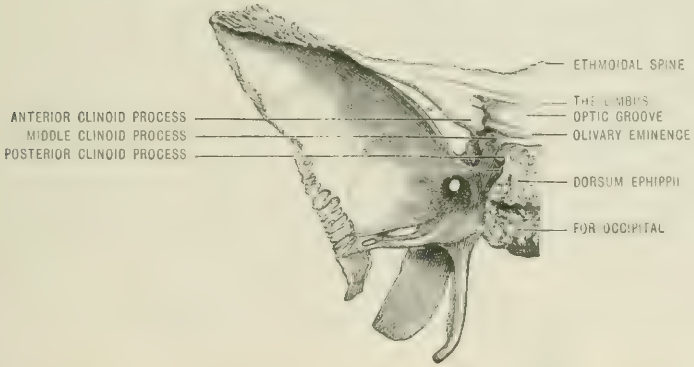
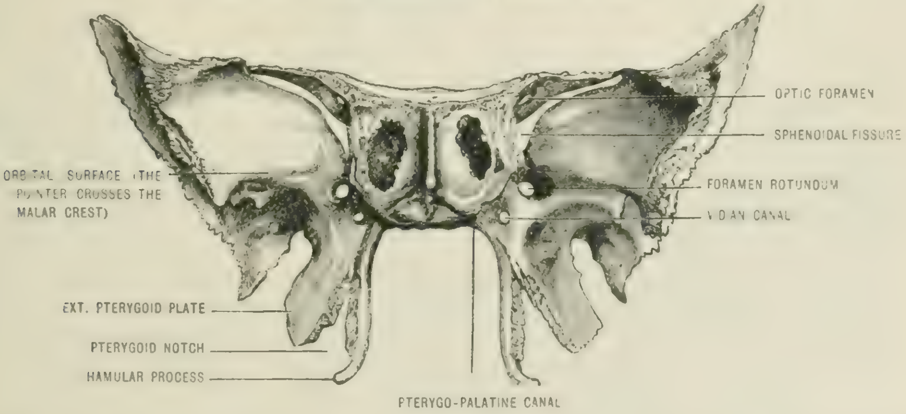
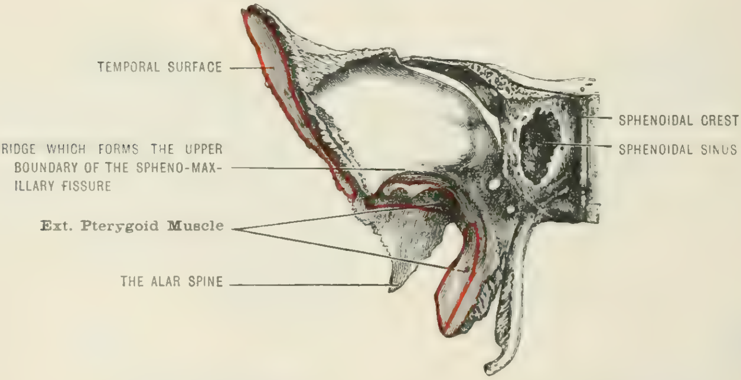

ANTERIOR CLINOID PROCESS
MIDDLE CLINOID PROCESS
POSTERIOR CLINOID PROCESS
ETHMOIDAL SPINE
THE LIMBUS
OPTIC GROOVE
OLIVARY EMINENCE
DORSUM EPHIPPII
FOR OCCIPITAL

Fig. 38.—The Sphenoid. (Anterior view.)


OPTIC FORAMEN
SPHENOIDAL FISSURE
ORBITAL SURFACE (THE POINTER CROSSES THE MALAR CREST)
FORAMEN ROTUNDUM
VIDIAN CANAL
EXT. PTERYGOID PLATE
PTERYGOID NOTCH
HAMULAR PROCESS
PTERYGO-PALATINE CANAL

The **greater wings** (ali-sphenoids) are two large plates of bone ankylosed to the body by means of the **lingulæ.** Each wing has three surfaces. The superior or **cerebral surface** is concave and smooth; it supports the temporo-sphenoidal lobe of the cerebrum, and presents several foramina. At the anterior and internal part is the **foramen rotundum** for the second division of the fifth nerve; behind and external to this is the **foramen ovale,** for the motor root and the third division of the fifth nerve, the small petrosal nerve, the small meningeal artery, and an emissary vein from the cavernous sinus. Behind and external to the foramen ovale is the small circular **foramen spinosum,** for the middle meningeal artery, its venæ comites, and the recurrent branch of the third division of the fifth nerve. To the inner side of the foramen ovale a small opening, the **foramen Vesalii,** is occasionally present; it transmits a vein. A foramen may exist near the foramen ovale for the small superficial petrosal nerve, the canaliculus innominatus. The **external surface** is divided by the prominent **malar crest** into an orbital and a temporo-zygomatic portion. The **orbital surface** forms the chief part of the outer wall of the orbit; its internal segment forms part of the spheno-maxillary fossa, and presents the anterior orifice of the foramen rotundum. Near the middle of the upper border there is a small tubercle for the origin of the outer head of the *external rectus* muscle; and at the highest part of this surface one or more foramina are often present, for the transmission of twigs from the middle meningeal artery to the orbit and the lachrymal gland. The **malar crest** is serrated for articulation with the malar bone; its lower angle, in many bones, articulates with the maxilla. A foramen exists in the suture between the sphenoid and malar, for the temporal twig of the orbital nerve. The surface of bone outside this ridge is subdivided by a low crest, the **pterygoid ridge.** The surface above the ridge forms part of the temporal fossa, and affords attachment to the *temporal* muscle; the part below the crest belongs to the zygomatic fossa; it furnishes attachment to the *external pterygoid* muscle, and is continuous with the outer surface of the external pterygoid plate; it contains the inferior orifices of the foramina spinosum, ovale, and Vesalii, and forms part of the roof of the zygomatic fossa.

FIG. 39.—RIGHT HALF OF SPHENOID. (Anterior view.)



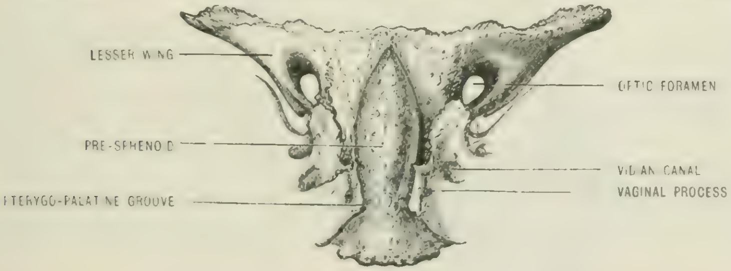
The **circumference** of the great wing, commencing at its anterior attachment to the body, is at first smooth, and forms the lower boundary of the **sphenoidal fissure**; this serves for the passage of the third, fourth, first division (ophthalmic) of the fifth, and the sixth nerves, with the ophthalmic vein. External to this, the margin is broad and serrated for the frontal bone; quite at the tip it is bevelled on its inner aspect for the anterior inferior angle of the parietal; behind this, the edge, at first thin and bevelled, becomes gradually broader, and deeply serrated for the squamosal, and runs into the prominent **alar spine** of the sphenoid, to which the spheno-mandibular ligament is attached and which is grooved internally by the chorda tympani nerve. That portion of the circumference extending from the spine to the body of the sphenoid articulates by the outer third with the petrosal, but the inner two-thirds forms the anterior boundary of the foramen lacerum medium, and contains the posterior orifice of the **Vidian canal.**

Projecting at right angles from the greater wing, near its junction with the lingulæ, are the **pterygoid processes.** Of these, the **external plate,** broad and thin, forms by its outer surface the inner wall of the zygomatic fossa, and affords attachment to the *external pterygoid* muscle. From its inner surface the *internal pterygoid* takes origin.

The **internal pterygoid plate** is narrower and longer than the external. Its inner surface forms part of the outer boundary of the nasal fossa, and by a thin ledge of bone, called the **vaginal process,** extends to the under surface of the basisphenoid to articulate with the ala of the vomer, and anteriorly with the sphenoidal process of the palate bone. Immediately above this ledge of bone is the **pterygo-palatine groove** (converted into a canal by the sphenoidal process of the palate bone), for an artery and nerve of the same name. At the point where the internal pterygoid plate comes into relation with the great wing and the lingula, there is the **Vidian canal.** This canal is 3 cm. long, and transmits the Vidian nerve and artery. The outer surface of the internal pterygoid plate forms the inner boundary of the **pterygoid fossa**; its posterior border is prolonged into a **hamular process,** smooth on its under aspect, for the bursa between it and the *tensor* (circumflexus) *palati.* From the lower third of the posterior border and the hamular process the *superior constrictor* of the pharynx takes origin.

The anterior borders of these processes diverge below, and have rough edges for articulation with the tuberosity of the palate bone; the gap between them is the **pterygoid notch.** Superiorly, the pterygoid processes form a triangular surface, which constitutes the posterior boundary of the spheno-maxillary fossa, and presents above the anterior orifice of the Vidian, and more internally the commencement of the pterygo-palatine canal. The anterior border of the internal pterygoid plate articulates with the posterior border of the vertical plate of the palate bone.

Fig. 40.—The Under Surface of Pre-Sphenoid at the Sixth Year.



The recess between the two pterygoid plates posteriorly is subdivided. The upper, smaller and shallower depression is the **scaphoid fossa**; it gives attachment to the *tensor* (circumflexus) *palati* externally, and the cartilage of the Eustachian tube internally. The lower, deeper and larger, is the **pterygoid fossa**; it lodges the *internal pterygoid* and *tensor palati* muscles. The fossa is completed by the tuberosity of the palate bone.

Articulations.—The sphenoid articulates with the following bones: ethmoid, frontal, parietal, temporal, epipteric, palate, vomer, occipital, malar, sphenoidal turbinals, and occasionally with the maxilla.

Muscles.—It gives origin to the following muscles:—

Temporal.
Internal pterygoid.
External pterygoid.
Tensor tympani.
Tensor palati.

External rectus of the eyeball.
Internal rectus " "
Superior rectus " "
Superior oblique " "
Levator palpebræ.

Ligaments.—The sphenoid has numerous intrinsic ligaments which occasionally ossify and produce adventitious foramina. Of these, the more important are:—

Inter-clinoid.—This passes from the anterior to the posterior clinoid processes.

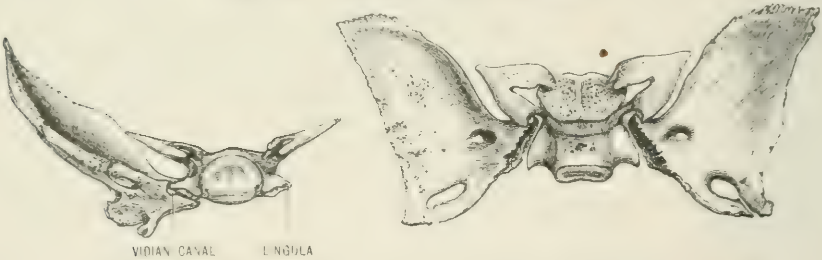
Carotico-clinoid.—From the anterior to the middle clinoid process. The ossification of this ligament gives rise to a ring of bone through which the internal carotid artery passes.

Pterygo-spinous.—This is attached to the spine of the sphenoid and the external pterygoid plate near the upper third.

Several other insignificant bands have received names, but they are of no importance.

Blood-supply.—The sphenoid is supplied by branches of the middle and small meningeal arteries; also the anterior deep temporal and other branches of the internal maxillary, such as the Vidian, pterygo-palatine and spheno-palatine. The body of the bone also receives twigs from the internal carotid.

Fig. 11.—The Sphenoid at Birth.

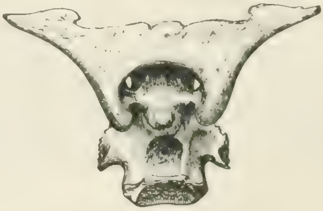


Ossification.—The sphenoid is ossified in cartilage from twelve ossific nuclei which appear in pairs. The nuclei are divisible into two sets,—those for the pre-sphenoid, and those for the post-sphenoid.

The **post-sphenoid** centres consist of four pairs disposed as follows:—One for each ali-sphenoid (great wing). A pair of median nuclei for the basi-sphenoid, and a nucleus for each lingula (sphenotic nucleus), and one for each internal pterygoid. The external pterygoid is an outgrowth from the great wing.

The **pre-sphenoid** centres consist of a nucleus for each orbito-sphenoid (lesser wings), and a median pair for the body of the pre-sphenoid. These nuclei appear at intervals from the eighth week to the end of the third month in the following order: ali-sphenoid, basi-sphenoid, lingulæ, internal pterygoids, orbito-sphenoid, and pre-sphenoid. The various earthy spots fuse together, so as to form at birth three pieces. The median piece consists of the basi-sphenoid and lingulæ, conjoined with the pre-sphenoid carrying the orbito-sphenoids; the two lateral pieces are the ali-sphenoids (greater wings) carrying the internal pterygoid plates. The greater wings are joined to the lingulæ by cartilage. The dorsum ephippii is cartilaginous at birth. In the course of the first year the orbito-sphenoids fuse in the middle line to form the **jugum sphenoidale,** which excludes the anterior part of the pre-sphenoid from the cranial cavity. The greater wings fuse with the lingulæ in the course of the first year.

Fig. 12.—The Jugum Sphenoidale.



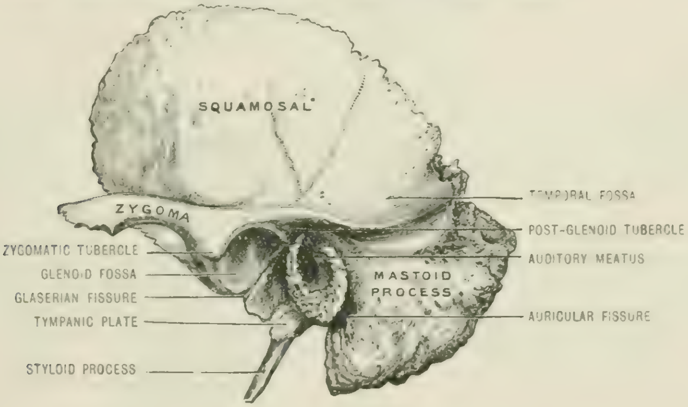
THE TEMPORAL BONES

The adult temporal bone consists of three parts, so firmly united as to afford little trace of its complex origin. At birth the three parts are easily separable as the **squamosal, petrosal,** and **tympanic.**

The **squamosal** resembles a large scale; it is attached at right angles to the petrosal, and forms part of the side wall of the skull. It is thin, and in places translucent. The outer surface is smooth and forms part of the temporal fossa; it presents one, and occasionally two nearly vertical grooves for the deep temporal arteries. A ridge of bone, the **supra-mastoid crest,** runs immediately above the external auditory meatus, and is continued onwards to the zygoma.

The **zygoma** is a narrow projecting bar of bone, jutting forwards and lying parallel with the squamosal. It has two surfaces and two borders. The outer surface is subcutaneous; the inner looks towards the temporal fossa. The inner surface and lower border give origin to the *masseter* muscle. The upper border receives the temporal fascia. The tip of the zygoma is serrated for articulation with the malar. Posteriorly, the lower border ends in a **tubercle,** which is the meeting point of two ridges; of these, the anterior passes inwards at right angles to the zygoma, and expands into the **articular eminence** which serves as an articular facet for the condyle of the mandible when the mouth is opened. The second ridge runs backwards and forms the upper boundary of the glenoid fossa, and curving downwards ends in a tubercle, the **post-glenoid tubercle,** immediately anterior to the **Glaserian fissure.** The oval deep depression between these ridges is the **glenoid fossa,** which receives the condyle of the mandible. This fossa is limited posteriorly by the Glaserian fissure.

FIG. 43.—THE LEFT TEMPORAL BONE. (Outer view.)



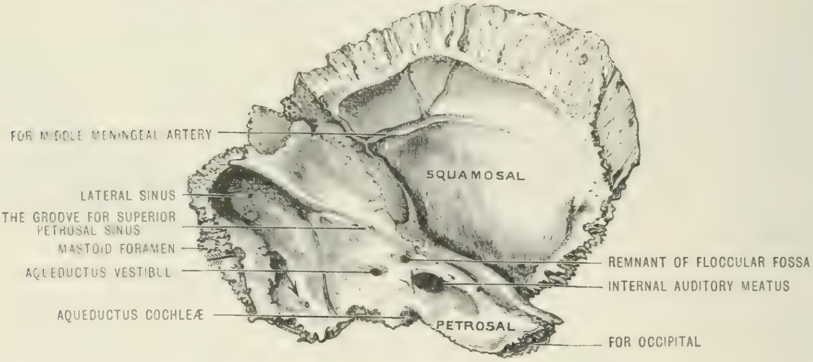
The inner surface of the squamosal presents furrows for the convolutions of the brain and grooves for the middle meningeal arteries. The line of union between the squamosal and petrosal is sometimes indicated by a persistent **petro-squamosal** suture. Rarely the two portions remain permanently separate.

The superior border of the squamosal is thin, and bevelled on the cerebral surface where it overlaps the parietal; anteriorly it is serrated for the posterior border of the greater wing of the sphenoid. Posteriorly it joins the rough serrated margin of the petrosal to form the parietal notch.

The **petrosal** element is a four-sided pyramid of very dense bone; its **base** is formed by the mastoid process; the **apex** is rough and forms part of the boundary of the foramen lacerum medium. Two sides of the pyramid project into the cranial cavity, of which one forms the posterior boundary of the middle fossa, and the other the anterior boundary of the posterior fossa of the cranium. Of the two remaining surfaces, one appears on the under surface of the skull, and the fourth constitutes the inner wall of the recess called the tympanum.

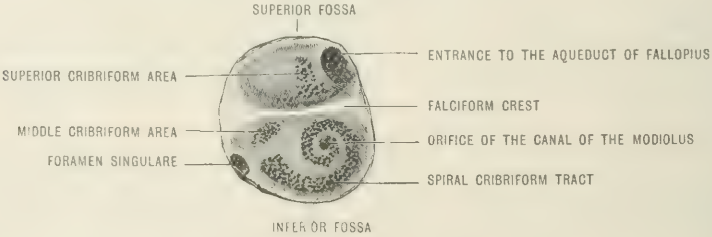
The **posterior surface** is bounded above by the superior border, which serves for the attachment of the tentorium cerebelli, and is grooved for the superior petrosal sinus; near the apex, this border presents the **trigeminal notch** (converted into a foramen by the tentorium) for the transmission of the trigeminal nerve. This border in old skulls sometimes terminates in a spiculum of bone—the **petro-sphenoidal process**—and extends to the dorsum ephippii, and completes a foramen (**petro-sphenoidal**) which transmits the sixth nerve. Near the middle of the posterior surface is an oblique inlet, the **internal auditory meatus**, which receives the auditory and facial nerves and the auditory artery. The meatus is about 10 mm. deep, and to be properly examined the surface of the bone should be cut away, or the parts studied in the petrosal of a fœtus at or near the ninth month, for it is at this date relatively large and shallow.

FIG. 44.—THE LEFT TEMPORAL BONE. (Inner view.)


FOR MIDDLE MENINGEAL ARTERY
LATERAL SINUS
THE GROOVE FOR SUPERIOR PETROSAL SINUS
MASTOID FORAMEN
AQUEDUCTUS VESTIBULI
AQUEDUCTUS COCHLEÆ
SQUAMOSAL
PETROSAL
REMNANT OF FLOCCULAR FOSSA
INTERNAL AUDITORY MEATUS
FOR OCCIPITAL

The fundus of the meatus is divided by a transverse ridge of bone, the *falciform crest*, into a superior and inferior fossa. Of these, the superior is the smaller, and presents anteriorly the beginning of the **aqueduct of Fallopius**; this transmits the seventh nerve. The rest of the surface above the crest is dotted with small foramina (the superior cribriform area) which transmit nerve-twigs to the fovea hemielliptica and the ampullæ of the superior and external semicircular canals. Below the crest there are two depressions and an opening. Of these, an anterior curled tract (the spiral cribriform tract) with a central foramen (foramen centrale cochleare) marks the base of the cochlea; the central foramen indicates the orifice of the canal of the modiolus, and the smaller foramina transmit the cochlear twigs of the auditory nerve. The posterior opening (foramen singulare) is for the nerve to the ampulla of the posterior semicircular canal. The middle depression (middle cribriform area) is dotted with minute foramina for the nerve-twigs to the saccule, which is lodged in the fovea hemispherica. The inferior fossa is subdivided by a low vertical crest. The fossa in front of the crest is the *fossula cochlearis*, and the recess behind it is the *fossula vestibularis*.

FIG. 45.—THE FORAMINA IN THE FUNDUS OF THE LEFT INTERNAL AUDITORY MEATUS OF A CHILD AT BIRTH $\left(\frac{4}{1}\right)$. (Diagrammatic.)

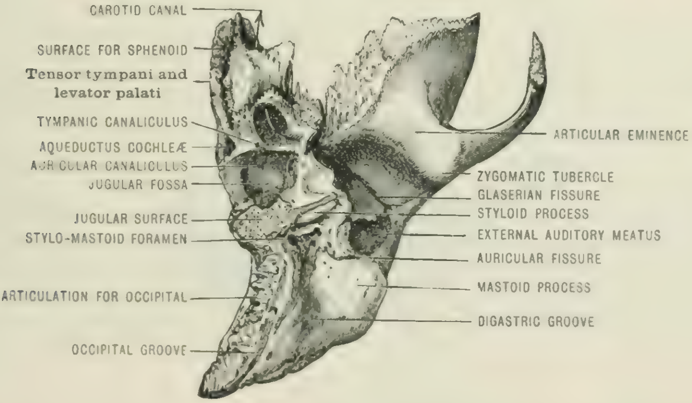

SUPERIOR FOSSA
ENTRANCE TO THE AQUEDUCT OF FALLOPIUS
SUPERIOR CRIBRIFORM AREA
FALCIFORM CREST
MIDDLE CRIBRIFORM AREA
ORIFICE OF THE CANAL OF THE MODIOLUS
FORAMEN SINGULARE
SPIRAL CRIBRIFORM TRACT
INFERIOR FOSSA

Behind the meatus is a small slit (**aqueductus vestibuli**) which lodges the ductus endolymphaticus; in the adult it is occupied by a small arteriole and venule and a process of dura mater. Occasionally a bristle can be passed along this passage into the vestibule. Above, and anterior to this, is a second slit also lodging a process of the dura mater. This is a remnant of the **floccular fossa,** so conspicuous in the fœtus. Posteriorly, this surface has a deep groove for the lateral sinus.

The **anterior face of the pyramid** is separated from the squamosal by the **petro-squamous suture,** which may persist throughout life. It presents the following points of interest: near the apex it has a shallow depression for the **Gasserian ganglion,** and the recess of dura mater (Meckel's cave) in which it lies. Behind these are two small foramina, overshadowed by a thin osseous lip. Of these, the larger and more internal is the **hiatus Fallopii,** which transmits a small artery from the middle meningeal and the greater petrosal nerve. The smaller and external foramen is for the lesser petrosal nerve. Still more externally there is a thin translucent plate of bone, the **tegmen tympani.** Behind, and slightly internal to this, there is a ridge formed by the **superior semicircular canal.**

The **inferior** or **basilar surface** is very irregular, and has the following points of interest. At the apex is a quadrilateral smooth space for the *tensor tympani* and *levator palati* muscles. Behind this is the large circular orifice of the **carotid canal,** for the transmission of the carotid artery and a plexus of sympathetic nerves. Internal to this, near the inner border of the bone, is the orifice of the **aqueductus cochleæ** (ductus perilymphaticus). In the adult it transmits a small vein from the cochlea to the internal jugular. Posteriorly is the elliptical **jugular fossa** with smooth walls for the ampulla which receives the lateral and inferior petrosal sinuses, and forms the commencement of the internal jugular vein. In the ridge of bone between the fossa and the carotid canal there is a small foramen, the **tympanic canaliculus,** for the tympanic branch of the glosso-pharyngeal nerve. On the outer wall of the fossa a similar minute foramen, the **auricular canaliculus,** permits the passage inwards of the auricular branch (Arnold's nerve) of the vagus nerve. Behind the fossa is the rough **jugular surface,** which receives the jugular process of the occipital. Firmly ankylosed to the inner surface of the **tympanic plate** is the **styloid process,** varying in length from one to five cm. At its base is the **stylo-mastoid** foramen, from which issues the facial nerve; the stylo-mastoid artery enters the **Fallopian canal** through this opening. Running backwards from this foramen are two grooves; the outer is the **digastric groove,** from which the *digastric* muscle arises. The inner is narrower and shallower; it lodges the occipital artery.

FIG. 46.—THE LEFT TEMPORAL BONE. (Inferior view.)

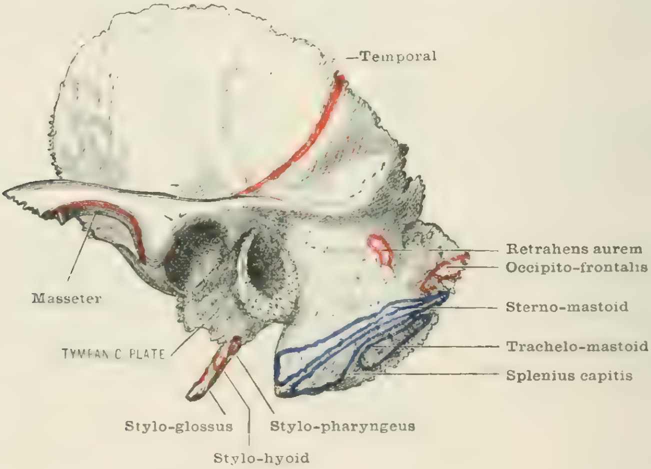

CAROTID CANAL
SURFACE FOR SPHENOID
Tensor tympani and levator palati
TYMPANIC CANALICULUS
AQUEDUCTUS COCHLEÆ
AURICULAR CANALICULUS
JUGULAR FOSSA
JUGULAR SURFACE
STYLO-MASTOID FORAMEN
ARTICULATION FOR OCCIPITAL
OCCIPITAL GROOVE
ARTICULAR EMINENCE
ZYGOMATIC TUBERCLE
GLASERIAN FISSURE
STYLOID PROCESS
EXTERNAL AUDITORY MEATUS
AURICULAR FISSURE
MASTOID PROCESS
DIGASTRIC GROOVE

Of the **outer surface,** the only part which appears externally is the mastoid process; the rest is occupied by a recess known as the tympanum. The **mastoid process** is a nipple-shaped prominence of bone, formed partly by the squamosal, but mainly by the petrosal. Its upper limit is the **supra-mastoid crest.** Below the crest an irregular furrow crosses the surface of the process from the parietal notch downwards, to the middle of the meatus. This furrow (squamo-mastoid) is often dotted with holes, and represents the line of union of squamosal and petrosal. The mastoid process gives attachment to the *sterno-mastoid, splenius capitis, trachelo-mastoid, occipito-frontalis,* and *retrahens aurem* muscles.

The **tympanum** is hidden by the *tympanic plate*, which extends downwards from the **Glaserian fissure** to form the **vaginal process.** Anteriorly it extends forwards and ankyloses with the outer wall of the carotid canal. The Glaserian fissure separates it from the squamosal. This fissure transmits the tympanic branch of the internal maxillary artery, and lodges the slender process of the malleus. A narrow subdivision of this fissure, **canal of Huguier,** is traversed by the chorda tympani nerve. The tympanic plate forms the anterior, lower, and part of the posterior walls of the external auditory meatus. It is limited posteriorly by the auricular fissure, through which the auricular twig of the vagus nerve issues.

The **external auditory meatus** assumes the form of an elliptical bony tube. Its outer margin is rough and gives attachment to the cartilaginous portion of the pinna. Between the posterior edge of the meatus and the mastoid process is the auricular fissure. The tympanic orifice of the meatus is smooth, and presents a well-marked groove for the tympanic membrane. This is very conspicuous in young bones. The direction of the meatus is somewhat oblique. In children, and occasionally in adults, a circular opening exists in the anterior wall of the meatus (fig. 53).

FIG. 47.—TEMPORAL BONE WITH MUSCLE ATTACHMENTS.



Articulations.—The temporal bone articulates with the occipital, parietal, sphenoid, malar, and by a movable joint with the mandible. Occasionally the squamosal presents a process which articulates with the frontal. A **fronto-squamosal** suture is common in the skulls of the lower races of men, and is normal in the skulls of the chimpanzee, gorilla, and gibbon.

The **muscles** connected with the temporal bone are:—

To the mastoid process	Sterno-mastoid. Splenius capitis. Trachelo-mastoid. Digastric. Occipito-frontalis. Retrahens aurem.

To the styloid process	Stylo-glossus. Stylo-hyoid. Stylo-pharyngeus.
To the zygoma	Masseter.
Intrinsic muscles	Stapedius. Tensor tympani.
To the petrosal	Levator palati.

Ligaments :—

Capsular
Interarticular
Internal lateral
External lateral
} of temporo-mandibular joint.

Stylo-hyoid.
Stylo-maxillary.
Petro-sphenoidal.

Ligaments connected with the **ear-bones** :—

Anterior ligament of malleus.
External ligament of malleus.
Superior ligament of malleus.
Ligament of incus.

The blood-supply.—Arteries supplying the temporal bone are derived from various sources. The chief are:—

Stylo-mastoid from posterior auricular: it enters the stylo-mastoid foramen.

Tympanic from internal maxillary: it passes through the Glaserian fissure.

Petrosal from middle meningeal: transmitted by the hiatus Fallopii.

Tympanic from internal carotid whilst in the carotid canal.

Auditory from the basilar: it enters the internal auditory meatus, and is distributed to the cochlea and vestibule.

Other less important twigs are furnished by the middle meningeal, the meningeal branches of the occipital, and by the ascending pharyngeal artery. The squamosal is supplied on its internal surface by the middle meningeal, and externally by the branches of the deep temporal from the internal maxillary.

Note.—The description of the Styloid Process and of the Ear-bones is given on pages 66–68.

THE TYMPANUM

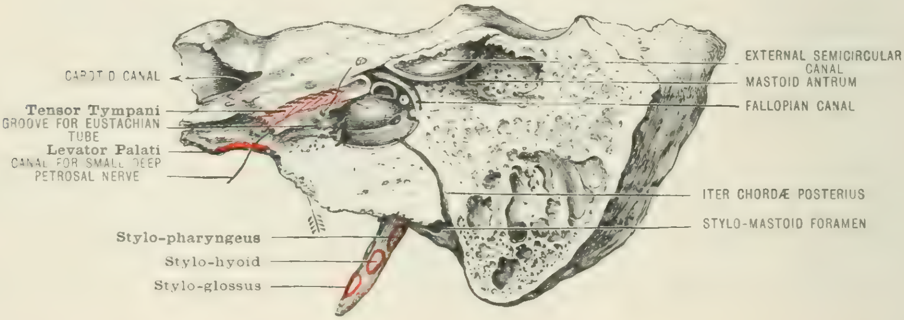
The tympanum is an irregular cavity in the temporal bone. At birth it is a recess in the outer wall of the petrosal, partially closed externally by the squamosal. When the various elements of the temporal bone coalesce, and the tympanic plate becomes fully developed, then the cavity is completely surrounded by bony walls, except where it communicates with the external auditory meatus.

The roof, or **tegmen tympani**, is a translucent plate of bone belonging to the petrosal; it separates the tympanum from the middle fossa of the skull. The floor is the plate of bone which forms the roof of the jugular fossa.

The inner wall is formed by the **external surface** of the petrosal bone, and presents the following points for study:—In the angle between it and the roof is a horizontal ridge which extends backwards as far as the posterior wall, and then turns downwards in the angle between the inner and posterior walls. This is the **Fallopian canal**; it is occupied by the facial nerve (seventh). Near the roof, but below the Fallopian canal, is the **fenestra ovalis**, which leads into the vestibule: this fenestra receives the **base** of the **stapes**. Below and in front of the fenestra ovalis is the **promontory**, which contains the commencement of the first turn of the cochlea. In the lower and posterior part of the promontory is the **fenestra rotunda**; this, in the recent state, is closed by the **secondary** membrane of the tympanum. In the macerated bone it leads into the spiral canal of the cochlea. The promontory is also furrowed by some delicate channels (sometimes canals) for the tympanic branch of the glosso-pharyngeal nerve, which enters the tympanum through the **tympanic canaliculus.** The posterior wall of the tympanum is formed by the mastoid process. At the superior and external angle of this wall an opening leads into the **mastoid antrum.** Immediately below this opening there is a small hollow cone, the **posterior pyramid**; its cavity is continuous with the descending limb of the Fallopian canal. One or more bony spiculæ often connect the apex of the pyramid with the promontory. The cavity of this cone is occupied by the *stapedius* and the tendon of the muscle emerges at the apex.

The roof and floor converge towards the anterior extremity of the tympanum, which is, in consequence, very narrow, and occupied by two canals: the lower for the Eustachian tube, the upper for the *tensor tympani* muscle. These grooves are sometimes described together as the **canalis musculo-tubarius.** In carefully prepared bones the upper canal is a small horizontal hollow cone (anterior pyramid), 12 mm. in length, which lodges the *tensor tympani* muscle; the apex is just in front of the fenestra ovalis, and is perforated to permit the passage of the tendon of the muscle. As a rule the thin walls of the canal are damaged, and represented merely by a thin ridge of bone. The posterior portion of this ridge projects into the tympanum, and is known as the **processus cochleariformis.** The thin septum between the canal for the tensor tympani and the tube is pierced by a narrow canal which is traversed by the small deep petrosal nerve. The outer wall is occupied mainly by the external auditory meatus. This opening is closed in the recent state by the tympanic membrane. The rim of bone to which the membrane is attached is incomplete above; the defect is known as the **notch of Rivinus.** Anterior to this notch, in the angle between the squamosal and the tympanic plate, is the **Glaserian fissure,** and the small passage which transmits the chorda tympani nerve sometimes called the **canal of Huguier.**

Fig. 48.—The Inner Wall of Tympanum.



The tympanic cavity may be divided into three parts. The part below the level of the superior margin of the external auditory meatus is the **tympanum proper**; the portion above this level is the **attic** of the tympanum; it receives the head of the malleus, the body of the incus, and leads posteriorly into a recess known as the mastoid antrum.

The mastoid antrum.—This is quite distinct from the mastoid cells. It is an air-chamber communicating with the attic of the tympanum. It is separated from the middle cranial fossa by the posterior portion of the tegmen tympani: the floor is formed by the mastoid portion of the petrosal: it communicates with the mastoid cells. The outer wall is formed by the squamosal below the supra-mastoid crest. In children, the outer wall is exceedingly thin, but in the adult it is of considerable thickness. The **external semicircular canal** projects into the antrum on its inner wall, and is very conspicuous in the fœtus.

A canal occasionally leads from the mastoid antrum through the petrous bone to open in the recess which indicates the position of the floccular fossa: it is termed the petro-mastoid canal. (Gruber.)

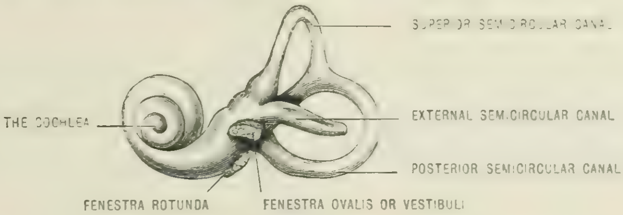
The Fallopian canal.—This canal begins at the anterior angle of the superior fossa of the internal auditory meatus, and passes directly outwards to the hiatus Fallopii; it then turns abruptly backwards and forms a horizontal ridge on the inner wall of the tympanum, lying in the angle between it and the tegmen tympani. It passes immediately above the fenestra ovalis, and extends as far backwards as the entrance to the mastoid antrum; here it comes into contact with the inferior aspect of the projection formed by the external semicircular canal. It then turns vertically downwards, running in the angle between the internal and posterior walls of the tympanum to terminate at the stylo-mastoid foramen.

The canal is traversed by the facial (seventh) nerve. Numerous openings exist in the walls of this passage. At the hiatus, the greater and smaller superficial petrosal nerves escape from, and a branch from the middle meningeal artery enters, the canal. In the vertical part of its course the cavity of the posterior pyramid opens into it. There is also a small orifice by which the auricular branch of the vagus joins the facial, and near its termination the **iter chordæ posterius** for the chorda tympani nerve leads from it into the tympanum.

The vestibule.—This is an oval chamber situated between the base of the internal auditory meatus and the inner wall of the tympanum, with which it communicates by way of the fenestra ovalis. Anteriorly the vestibule leads into the cochlea, and posteriorly it receives the extremities of the semicircular canals. It measures about 3 mm. transversely, and is somewhat longer antero-posteriorly.

Its inner wall presents at the anterior part a circular depression, the **fovea hemispherica,** which is finely perforated for the passage of nerve-twigs. This fovea is separated by a vertical ridge (the **crista vestibuli**) from the vestibular orifice of the **aqueductus vestibuli,** which passes obliquely backwards to open on the posterior surface of the petrosal bone.

Fig. 49.—The Left Osseous Labyrinth. (After Henle. From a cast.


SUPERIOR SEMICIRCULAR CANAL
THE COCHLEA
EXTERNAL SEMICIRCULAR CANAL
POSTERIOR SEMICIRCULAR CANAL
FENESTRA ROTUNDA
FENESTRA OVALIS OR VESTIBULI

The roof contains an oval depression—the **fovea hemielliptica.** Anteriorly the vestibule leads into the **cochlea.** Posteriorly it receives the five openings of the semicircular canals.

The **semicircular canals** are three in number. Each forms about two-thirds of a circle; they lie in different planes. One extremity of each canal is dilated to form an **ampulla.**

The **superior canal** lies transversely to the long axis of the petrosal, and is nearly vertical; its highest limb makes a projection on the anterior surface of the bone. The ampulla is at the outer end; the inner end opens into the vestibule conjointly with the superior limb of the posterior canal.

The **posterior canal** is nearly vertical and lies antero-posteriorly. It is the longest of the three; its upper extremity joins the inner limb of the superior canal, and opens in common with it into the vestibule. The lower is the ampullated end.

The **external canal** is placed horizontally and arches outwards; its external limb forms a prominence in the mastoid antrum. This canal is the shortest; its ampulla is at the outer end near the fenestra ovalis.

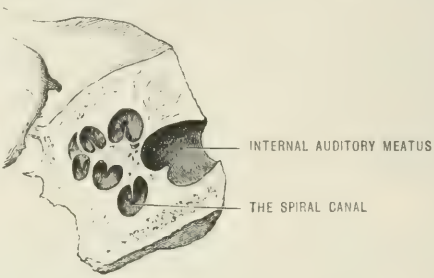
The cochlea.—This is a cone-shaped cavity lying with its base upon the internal auditory meatus, and the apex directed outwards. It measures about five millimetres in length, and the diameter of its base is about the same. The centre of this cavity is occupied by a column of bone—the **modiolus**—around which a delicate bony lamella appears to be wound. This lamella is the **osseous spiral lamina,**

which gives attachment to the structures which form collectively the membranous cochlea. The lamina makes two and a half turns in all. The first turn is the largest, and forms a bulging, the **promontory,** on the inner wall of the tympanum. The lamina terminates at the apex of the cochlea in a hooklike process—the **hamulus.**

The modiolus is traversed by a central canal, and presents many canaliculi for the transmission of the twigs of the cochlear division of the auditory nerve. There is also a canal which winds round the modiolus at the base of the spiral lamina, known as the **spiral canal** of the **modiolus.**

The portion of the cochlea above the lamina is the **scala vestibuli**; the part below, that is, on the basal aspect of the lamina, is the **scala tympani**; it opens into the tympanum by way of the fenestra rotunda. Near the commencement of the scala tympani, and close to the fenestra rotunda, is the cochlear orifice of the **aqueductus cochleæ** (ductus perilymphaticus). In the adult this opens on the inferior surface of the petrosal near the apex, and transmits a small vein from the cochlea to the jugular fossa.

Fig. 50.—The Cochlea in Saggital Section. (After Henle.)



Measurements of the principal parts connected with the auditory organs:—

Internal auditory meatus	Length of anterior wall, 13–14 mm. “ posterior wall, 6·7 mm.
External auditory meatus . . .	14–16 mm. (Gruber.)
Tympanum	Length, 13 mm. Height in centre of cavity, 15 mm. Width opposite the membrana tympani, 2 mm. “ “ tubal orifice, 3–4 mm. (Von Tröltsch.)

The capsule of the osseous labyrinth is in length 22 mm. (Schwalbe.)
Superior semicircular canal measures along its convexity 20 mm.
The posterior “ “ “ “ “ 22 mm.
The external “ “ “ “ “ 15 mm.
The canal is in diameter 1·5 mm. (Huschke.)
The ampulla of the canal, 2·5 mm.

The Ossification of The Temporal Bone

At birth the temporal bone consists of three parts easily separable in the macerated skull: they are the *petrosal*, *squamosal*, and the *tympanic*. (The styloid process is cartilaginous with the exception of its basal element, the tympano-hyal, which, with the ear-bones, will be described with the appendicular elements of the cranium.)

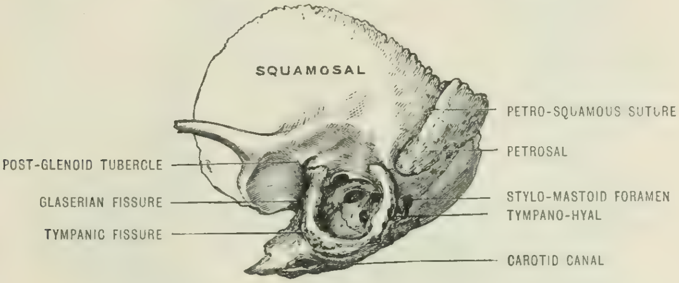
The squamosal and tympanic bones develop in membrane. The squamosal is formed from one centre, which appears as early as the eighth week. Ossification extends into the zygoma, which grows concurrently with the squamosal. At first the tympanic border is nearly straight, but soon assumes its characteristic horseshoe shape. At birth the post-glenoid tubercle is conspicuous, and at the hinder end of the squamosal there is a recess where it comes into relation with the mastoid antrum. The centre appears for the tympanic bone about the twelfth week. At birth it is a horseshoe-shaped ossicle slightly ankylosed to the lower border of the squamosal, the open arms being directed upwards. The tip of the anterior arm terminates in a small irregular process, and the inner aspect presents, in the lower half of its circumference, a groove for the reception of the tympanic membrane.

Up to the middle of the fifth month the periotic capsule is cartilaginous; it then ossifies so rapidly that by the end of the sixth month its chief portion is converted into porous bone. The ossific material is deposited in four centres, or groups of centres, named according to their relation to the ear-capsule in its embryonic position.

The nuclei are deposited in the following order:—

1. The **opisthotic** appears at the end of the fifth month. The osseous material is seen first on the promontory, and it quickly surrounds the fenestra rotunda from above downwards, and forms the floor of the vestibule, the lower part of the fenestra ovalis, and the internal auditory meatus; it also invests the cochlea. Subsequently a plate of bone arises from it to surround the internal carotid artery and form the floor of the tympanum.

FIG. 51.—THE TEMPORAL BONE AT BIRTH. (Outer view.)



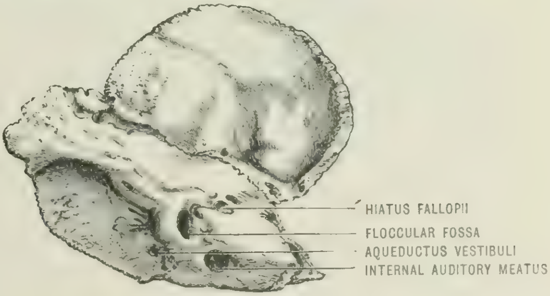
2. The **pro-otic** nucleus is deposited behind the internal auditory meatus near the inner limb of the superior semicircular canal. It covers in a part of the cochlea, the vestibule, and the internal auditory meatus, completes the fenestra ovalis, and invests the superior semicircular canal.

3. The **pterotic** nucleus ossifies the tegmen tympani and covers in the external semicircular canal; the ossific matter is first deposited over the outer limb of this canal.

4. The **epiotic** is the last to appear, and is first seen at the most posterior part of the posterior semicircular canal; it is often double. This centre gives rise to the mastoid process.

At birth the bone is of loose and open texture, resembling biscuit or unglazed porcelain, thus offering a striking contrast to the dense and ivory-like petrosal of the adult. It also differs from the adult bone in several other particulars. The floccular fossa is widely open and conspicuous. Voltolini has pointed out that a small canal leads from the floor of the floccular fossa and opens posteriorly on the mastoid surface of the bone; it may open in the mastoid antrum. The hiatus Fallopii is unclosed, and the tympanic recess is filled with gelatinous connective tissue. The mastoid process is not developed, and the jugular fossa is a shallow depression.

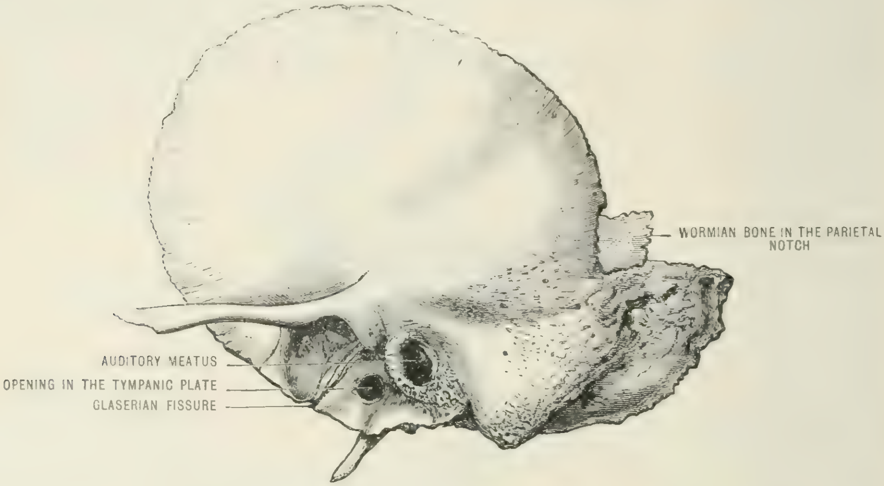
FIG. 52.—TEMPORAL BONE AT BIRTH. (Inner view.)



After birth the parts grow rapidly. The tympanum becomes permeated with air; the various elements fuse; and the tympanic annulus grows rapidly and forms the tympanic plate. Growth in the tympanic bone takes place most rapidly from the tubercles at its upper extremities, and in consequence of the slow growth of the lower segment a deep notch is formed; gradually the tubercles coalesce, leaving a foramen in the anterior part of the bony meatus which persists until puberty, and even in the adult. In most skulls a cleft capable of receiving the nail remains between the tympanic element and the mastoid process; this is the auricular fissure. The anterior portion of the tympanic plate forms with the inferior border of the squamosal a cleft known as the Glaserian fissure, which is subsequently encroached upon by the growth of the petrosal. As the tympanic plate increases in size it joins the outer wall of the carotid canal and presents a prominent lower edge, known as the vaginal process.

The **mastoid process** becomes distinct about the first year, coincident with the obliteration of the petro-squamous suture. It increases in thickness by deposit from the periosteum. Towards puberty, rarely earlier, the process becomes pneumatic, the air-cells being lined by delicate mucous membrane. In old skulls the air-cells may extend into the jugular process of the occipital bone.

FIG. 53.—TEMPORAL BONE AT THE SIXTH YEAR.


WORMIAN BONE IN THE PARIETAL NOTCH
AUDITORY MEATUS
OPENING IN THE TYMPANIC PLATE
GLASERIAN FISSURE

At birth the mastoid antrum is relatively large and bounded externally by a thin plate of bone belonging to the squamosal. As the mastoid increases in thickness the antrum comes to lie at a greater depth from the surface and becomes relatively smaller.

THE PARIETAL

The two parietals form a large portion of the vault and sides of the skull; they are interposed between the frontal anteriorly and the occipital posteriorly. Each parietal presents two surfaces, four borders, and four angles. The external surface is convex and smooth: the convexity, best marked in young bones, is greatest near the centre, which is termed the **parietal eminence.** Crossing the middle of the bone are the two **temporal ridges**; the lower is frequently the better marked, and limits the origin of the *temporal* muscle. The upper ridge is less constant, and gives attachment to the temporal fascia. The internal surface is concave and marked with depressions corresponding to the cerebral convolutions. Numerous vertical deep furrows for the branches of the middle meningeal artery radiate from the anterior inferior angle and lower border of the bone. Along the superior margin of the bone there is a groove which, when articulated with the opposite bone, forms a furrow which receives the superior longitudinal sinus. In adult bones numerous deep circular depressions for Pacchionian bodies are found near this groove. The superior border is deeply serrated for the opposite parietal, the union with which forms the **sagittal suture.** The anterior and posterior borders are deeply serrated: the anterior articulates with the frontal to form the **coronal,** and the posterior with the squamo-occipital to form the **lambdoid sutures.** The inferior border is bevelled and overlapped by the squamosal to form the **squamous suture.** Of the angles, the anterior inferior is prolonged downwards and articulates with the summit of the greater wing of the sphenoid. The posterior inferior angle articulates with the mastoid portion of the petrosal; on its inner surface it has a horizontal groove for lodging a portion of the lateral sinus. The superior angles present nothing worthy of note.

Fig. 54.—The Left Parietal. (Outer surface.)

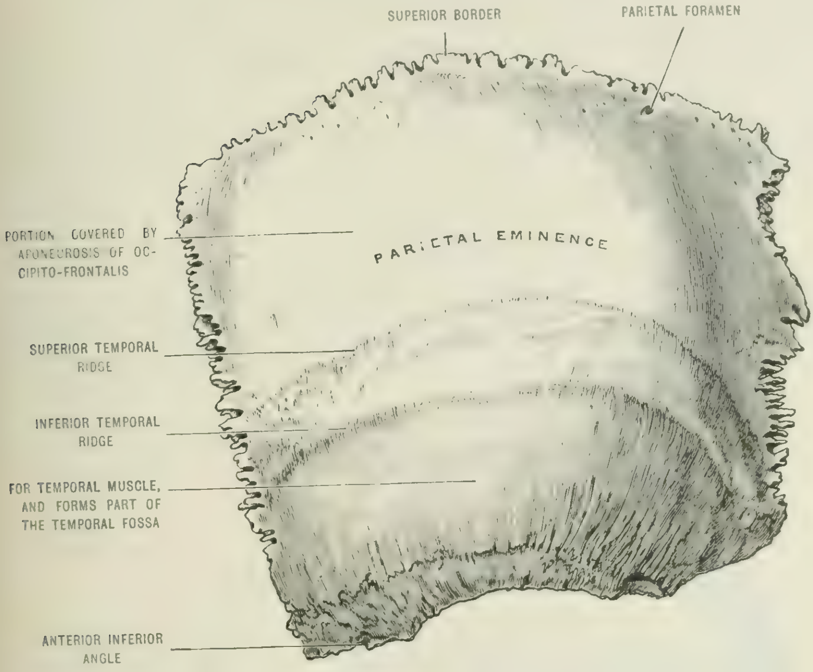
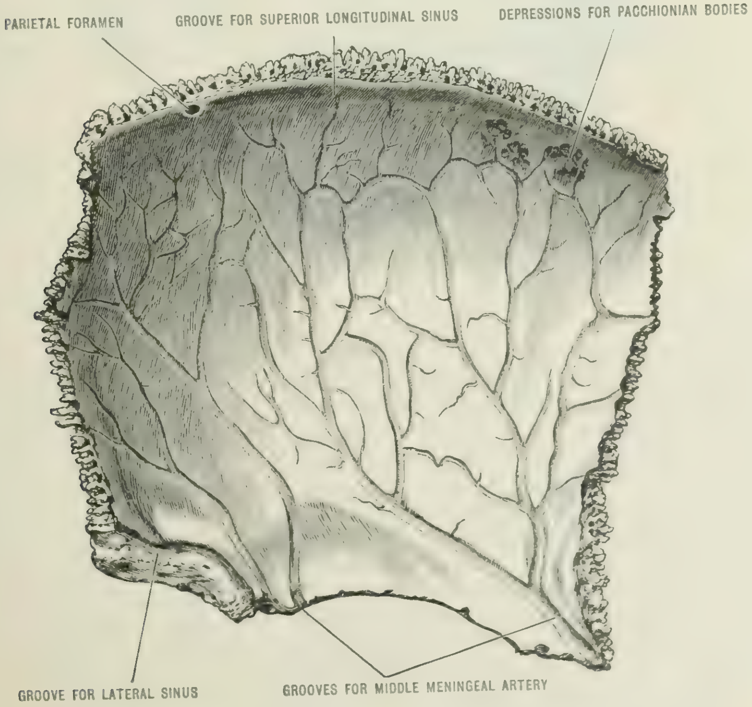

SUPERIOR BORDER
PARIETAL FORAMEN
PORTION COVERED BY APONEUROSIS OF OCCIPITO-FRONTALIS
PARIETAL EMINENCE
SUPERIOR TEMPORAL RIDGE
INFERIOR TEMPORAL RIDGE
FOR TEMPORAL MUSCLE, AND FORMS PART OF THE TEMPORAL FOSSA
ANTERIOR INFERIOR ANGLE

Fig. 55.—The Left Parietal. (Inner surface.)


PARIETAL FORAMEN
GROOVE FOR SUPERIOR LONGITUDINAL SINUS
DEPRESSIONS FOR PACCHIONIAN BODIES
GROOVE FOR LATERAL SINUS
GROOVES FOR MIDDLE MENINGEAL ARTERY

Articulations.—The parietal articulates with its fellow, the occipital, squamosal, frontal, sphenoid, and the epipteric bones when present. Occasionally the squamosal and epipteric may exclude the parietal from union with the greater wing of the sphenoid.

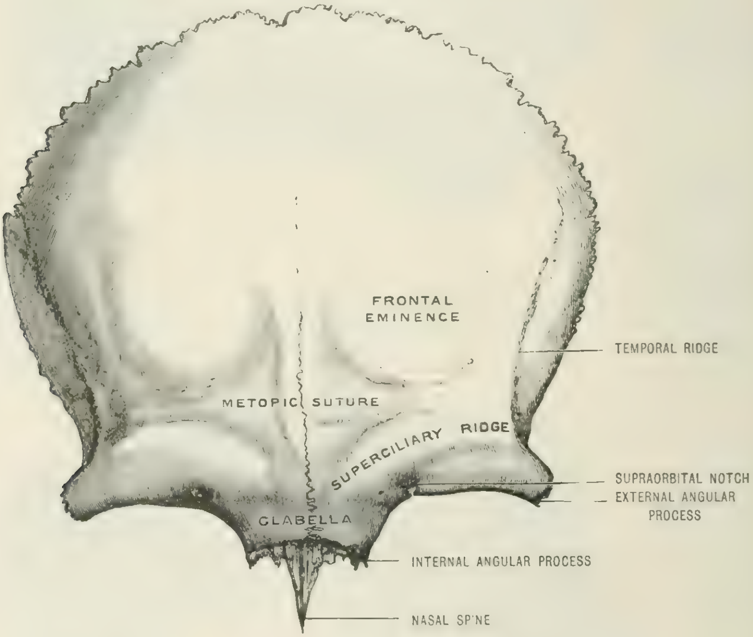
Blood-supply.—From the middle meningeal, occipital, and supraorbital arteries.

Ossification.—The parietal ossifies from an earthy spot deposited in the outer layer of the membranous wall of the skull about the seventh week. This bone is sometimes divided by a horizontal suture.

THE FRONTAL

This bone bears much the same relation to the anterior part of the skull that the occipital bears to the posterior. It has, not inaptly, been compared to a cockle shell. The inner or posterior surface is concave, forming a deep fossa for the reception of the frontal lobes of the cerebrum. There is a gap in the lower part of the bone known as the **ethmoidal notch,** which overlaps by its thin edges the cribriform plate of the ethmoid and forms, with that bone, the internal orifices of the anterior and posterior **ethmoidal canals.** The anterior part of this notch articulates with the crista galli, and the small hole in the line of suture is the **foramen cæcum.** Prolonged vertically upwards from the point of union with the crista is a ridge of bone, which gradually opens out to form a furrow for the reception of the superior longitudinal sinus; the ridge serves for the attachment of the anterior part of the falx cerebri. The thin laminæ of bone on each side of the ethmoidal notch are termed **orbital plates,** because they form the greater part of the roof of each orbit. As a rule, they present deep depressions for the convolutions on the orbital surface of the cerebrum. The rest of the cerebral surface of the frontal is fairly smooth, and presents a few furrows for meningeal arteries, and, near the median groove, pits for Pacchionian bodies.

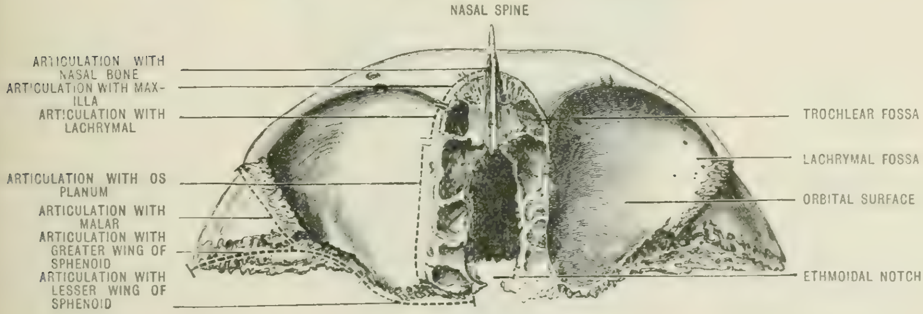
FIG. 56.—THE FRONTAL. (Anterior view.)



The external surface is convex and smooth, often divided by an imperfect fissure, the remains of the **metopic suture,** which indicates the line of union of the two bones representing the frontal in early life. On each side of this suture a little below the centre is the **frontal eminence.** Below the eminences, separated by shallow grooves, are the two converging **superciliary ridges,** which approach each other in the median line to form the **nasal eminence.** The smooth space bounded by the converging superciliary ridges is the **glabella.** Below these ridges the bone presents the sharp **supraorbital ridges** which end internally at the **internal angular,** and externally at the **external angular processes.** Each ridge has a narrow, deep **supraorbital notch** (sometimes a complete foramen) at the junction of the inner with the middle third. At the bottom of this notch or foramen a small opening communicates with the diploë. The external angular processes are prominent and articulate with the malar bones; from each process a ridge extends upwards and backwards, marking off the lateral aspect of the bone, where it assists in the formation of the temporal ridge and fossa. The internal angular processes articulate with the lachrymal bones, and are separated by a serrated interval, the **nasal notch,** which receives the upper borders of the nasal bones, and outside these the nasal processes of the maxillæ. The notch has in the middle a long pointed process, the **nasal spine,** which lies between the upper part of the nasal bones and the mesethmoid. On each side of the spine an opening leads into the large **frontal sinuses.**

The under surfaces of the orbital plates are smooth and concave; they form the roofs of the orbits. Each is sharply limited anteriorly by the supraorbital ridge, and presents at the outer angle the **lachrymal fossa** for the reception of the lachrymal gland. Near the internal angle there is the small shallow **supratrochlear fossa** for the pulley of the superior oblique muscle. A sharp ridge runs backwards from the internal angular process, and articulates successively with the lachrymal and the os planum of the ethmoid. It has two notches, which are converted into the anterior and posterior ethmoidal canals by articulation with the os planum. The posterior border of each orbital plate articulates with the lesser wing of the sphenoid (orbito-sphenoid), and is continuous with a rough triangular surface for the greater wing (ali-sphenoid). This triangular surface is continuous anteriorly with the serrated malar ridge of the frontal, and, laterally, with that border of the bone which articulates with the parietals to form the coronal suture. Between the ethmoidal notch and the inner margin of the orbital surface there is an irregular surface which forms the roofs of the ethmoidal cells.

FIG. 57.—THE FRONTAL BONE. (Inferior view.)


NASAL SPINE
ARTICULATION WITH NASAL BONE
ARTICULATION WITH MAXILLA
ARTICULATION WITH LACHRYMAL
ARTICULATION WITH OS PLANUM
ARTICULATION WITH MALAR
ARTICULATION WITH GREATER WING OF SPHENOID
ARTICULATION WITH LESSER WING OF SPHENOID
TROCHLEAR FOSSA
LACHRYMAL FOSSA
ORBITAL SURFACE
ETHMOIDAL NOTCH

Articulations.—The frontal articulates with the parietal, sphenoid, ethmoid, lachrymal, malar, maxilla, and nasal bones; with the epipterics when present, and occasionally (as explained on page 38) with the squamosal, and with the sphenoidal turbinal when it creeps into the orbit.

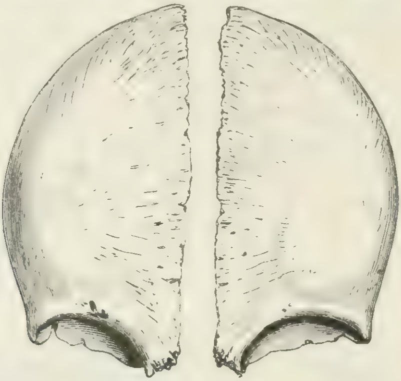
It has the following *muscles* attached to it:—

Corrugator supercilii.
Temporal.
Occipito-frontalis.
Orbicularis palpebrarum.

The blood-supply.—Arterial twigs derived from the middle and small meningeal arteries enter it on the cerebral, and branches from the frontal and supraorbital arteries on the outer surface. The horizontal plate derives twigs from the ethmoidal and other branches of the ophthalmic artery.

Ossification.—The frontal develops from two earthy spots deposited in the outer layer of the membranous wall of the cranium, in the situations ultimately known as the frontal eminences. These nuclei appear about the eighth week, and quickly spread through the membrane. At birth the bones are quite distinct. Subsequently they articulate with each other in the median line to form the metopic suture. In a few cases, the bones remain distinct throughout life. In the majority of cases the suture is obliterated; ankylosis commences about the second year. In adult skulls, traces of the metopic suture may often be seen in the region of the glabella.

Fig. 58.—The Frontal Bone at Birth.



After the two halves of the bone have united, osseous material is deposited at the lower end of the metopic suture to form the nasal spine, which is one of the distinguishing features of the human frontal bone. The spine appears about the twelfth year, and soon consolidates with the bone above. Accessory nuclei are sometimes seen between this bone and the lachrymal; they may persist as Wormian ossicles.

The frontal sinuses appear about the seventh year as prolongations from the anterior ethmoidal cells. Occasionally they invade the horizontal plate, and extend over the roof of the orbit.

THE EPIPTERIC AND WORMIAN BONES

The epipterics are bones of variable size which occupy the antero-lateral fontanelles, regions indicated in the adult skull by the name **pterion.** Each epipteric bone is wedged between the squamosal, frontal, greater wing of sphenoid, and the parietal, and is present in most skulls between the second and fifteenth year. After that date it may persist as a separate ossicle, or unite with the frontal or the squamosal. In this case it will cause a fronto-squamosal suture, and exclude the parietal from the sphenoid. More commonly the epipteric joins the sphenoid. In some skulls it is scarcely as large as a split pea, in others it is as broad as the thumb-nail. The epipteric bone is pre-formed in membrane, and appears in the course of the first year.

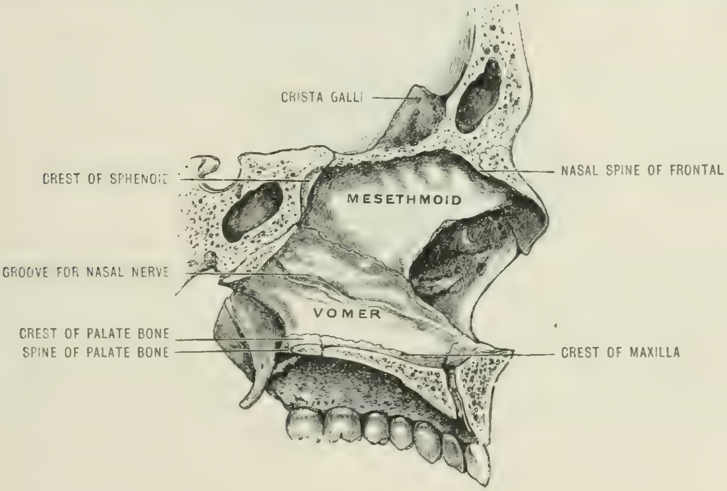
The **Wormian bones** are small, irregular-shaped ossicles, often found in the sutures of the skull, especially those in relation with the parietal bones. Wormian bones sometimes occur in great number; as many as a hundred have been counted in one skull. They are rarely present in the facial sutures.

THE ETHMOID

The ethmoid is a bone of delicate texture, situated at the anterior part of the skull-base; it is roughly cuboidal in shape, and its delicacy is due to the fact that it is honeycombed by air-cells. The bone consists of four parts: the horizontal or cribriform plate, two lateral masses, and a perpendicular plate.

The **cribriform plate** forms part of the anterior cerebral fossa, and is received into the ethmoidal notch of the frontal bone. Standing vertically upon this plate is the **crista galli.** To the posterior border of the crista the falx cerebri is attached; this border divides posteriorly to enclose the ethmoidal spine of the sphenoid. The anterior aspect of the base of the crista constitutes the anterior border of the cribriform plate; it is rough for articulation with the frontal. In the suture between the two bones there is usually an opening, the **foramen cæcum,** which when present transmits a small vein. On each side of the crista galli the cribriform plate lodges the olfactory bulb, and is perforated for the transmission of the filaments of the olfactory nerves. On each side, near the anterior part of the crista, there is a narrow longitudinal slit for the nasal branch of the fifth nerve.

FIG. 59.—SECTION THROUGH THE NASAL FOSSA TO SHOW THE MESETHMOID.



The **perpendicular plate** (mesethmoid) is directly continuous with the crista on the under aspect of the cribriform plate. It is a lamella of bone, trapezoid in shape, which forms the upper part of the nasal septum; usually it is laterally deflected. Its anterior border articulates with the nasal spine of the frontal, and the crest of the nasal bones. The inferior border has the triangular cartilage attached to it. The posterior border is subdivided: the upper half articulates with the crest of the sphenoid, and the lower articulates with the vomer. The surfaces of this plate present, especially in their upper parts, numerous foramina for vessels, and grooves for filaments of the olfactory nerves.

The **lateral mass,** or **labyrinth,** of the ethmoid consists of two scroll-like pieces of bone, the **superior** and **inferior turbinals** (ethmo-turbinals); a smooth, quadrilateral plate of bone, the **os planum,** and a number of air-cells.

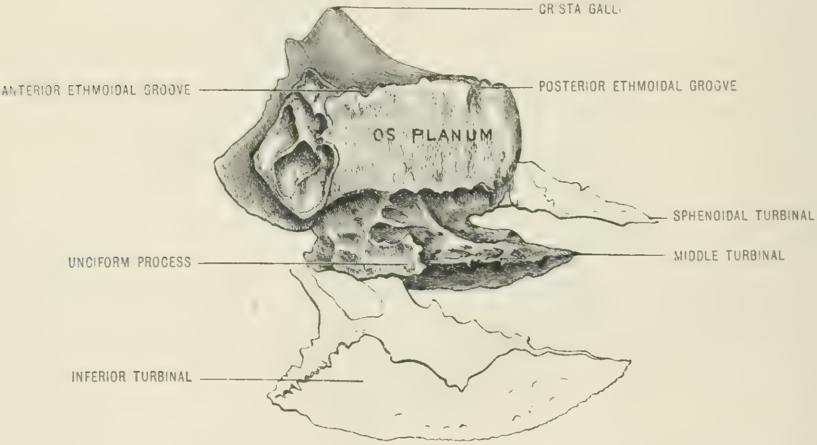
The **os planum** is on the outer side of the lateral mass, and forms a large portion of the inner wall of the orbit. By the anterior border it articulates with the lachrymal, by the posterior border with the sphenoid and the orbital process of the palate bone; the inferior border articulates with the inner margin of the orbital plate of the maxilla, and by the superior border with the horizontal plate of the frontal. Two notches in the superior border lead into grooves running horizontally across the lateral masses to the cribriform plate. These **ethmoidal grooves** are converted into *canals* by the frontal bone. The anterior canal transmits the anterior ethmoidal artery and nasal nerve; the posterior is for the posterior ethmoidal artery, and a branch of the nasal nerve.

The superior and middle **turbinals** project on the inner aspect of the lateral mass; they coalesce anteriorly, but are separated posteriorly by a space, termed the **superior meatus.** Each turbinal has an attached upper, and a free, slightly convoluted, lower border. In the recent state they are covered with mucous membrane, and present numerous foramina for blood-vessels, and grooves for twigs of the olfactory nerves.

On the under surface of each lateral mass, near the anterior corner of the os planum, an irregular lamina of bone projects downwards and backwards. This is the **unciform process**: it articulates with the ethmoidal process of the inferior turbinal, and forms a small part of the inner wall of the antrum. The anterior part of the lateral mass projects forwards in front of the os planum and articulates with the inner surface of the nasal process of the maxilla.

The **ethmoidal cells** occupy the space between the os planum and the turbinals; they are divided by a thin septum into an anterior and a posterior set. The cells are imperfect in the ethmoid; they require the juxtaposition of other bones to make them complete. Above, they are closed by the horizontal plate of the frontal, posteriorly by the sphenoidal turbinal and the orbital process of the palate, inferiorly by the maxilla, and anteriorly by the lachrymal. The anterior set communicate with the frontal cells above, whilst below they open into the middle meatus of the nose by a sinuous canal, the **infundibulum.** The posterior cells open into the superior meatus, and occasionally communicate with the sphenoidal cells.

FIG. 60.—THE ETHMOID. (Side view.)



The cells are sometimes divided into groups, according to the bone which lies in immediate juxtaposition. Those along the superior edge are the **fronto-ethmoidal**; those beneath the lachrymal, **lachrymo-ethmoidal**, usually two in number. Those along the lower edge are the **maxillo-ethmoidal**; and posteriorly there are the **spheno-ethmoidal**, completed by the sphenoidal turbinals, and a **palato-ethmoidal** cell.

Articulations.—The ethmoid articulates with the frontal, sphenoid, two palate bones, two nasals, vomer, two inferior turbinals, the sphenoidal turbinals, two maxillæ, and two lachrymal bones. The posterior surface of each lateral mass comes into relation with the sphenoid on each side of the crest and rostrum, and helps to close in the sphenoidal sinus.

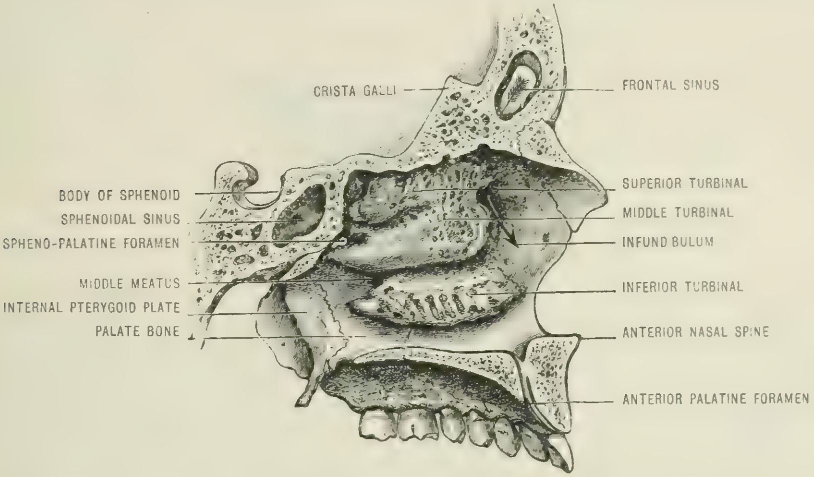
Blood-supply.—The anterior and posterior ethmoidal, and from the nasal or spheno-palatine branch of the internal maxillary artery.

Ossification.—The ethmoid has three centres of ossification. Of these, a nucleus appears in the fourth month of intra-uterine life in each lateral cartilage.

At birth this bone is represented by two scroll-like bones, very delicate, and covered with irregular depressions, which give it a worm-eaten appearance. Six months after birth a nucleus appears in the ethmo-vomerine plate for the mesethmoid. This gradually extends into the crista galli. During the third year the lateral masses and the mesethmoid (perpendicular plate) ankylose. The cribriform plate is derived from the lateral masses.

The ethmoidal cells do not make their appearance before the third year, and they gradually produce attenuation of the lateral masses. In many places there is so much absorption of bone that the cells perforate the ethmoid in situations where it is overlapped by other bones. Along the lower border of the bone, near its articulation with the maxilla, the absorption leads to the partial detachment of a narrow strip known as the uncinate or unciform process. Sometimes a second but smaller hook-like process is formed, above and anterior to the large one. This process is so very fragile that it is difficult to preserve it in disarticulated bones. The relations of the uncinate process are best studied by removing the outer wall of the antrum.

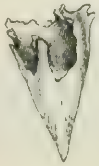
FIG. 61.—SECTION THROUGH THE NASAL FOSSA TO SHOW THE LATERAL MASS OF THE ETHMOID. IT SHOWS ALSO THE OUTER WALL OF THE LEFT NASAL FOSSA.


CRISTA GALLI
FRONTAL SINUS
BODY OF SPHENOID
SPHENOIDAL SINUS
SPHENO-PALATINE FORAMEN
MIDDLE MEATUS
INTERNAL PTERYGOID PLATE
PALATE BONE
SUPERIOR TURBINAL
MIDDLE TURBINAL
INFUNDIBULUM
INFERIOR TURBINAL
ANTERIOR NASAL SPINE
ANTERIOR PALATINE FORAMEN

THE SPHENOIDAL TURBINAL

These bones (often referred to as the bones of Bertin) are two hollow cones, flattened externally in three planes. They may be obtained as distinct ossicles about the fifth year. At this date they are wedged in between the under surface of the pre-sphenoid and the orbital and sphenoidal processes of the palate bone. The apex of the cone is directed backwards, and appears near the vaginal process of the sphenoid. Of its three surfaces, the outer one is in relation with the spheno-maxillary fossa, and occasionally extends upwards between the sphenoid and the os planum of the ethmoid to appear on the inner wall of the orbit (fig. 64).

FIG. 62.—THE SPHENOIDAL TURBINAL AT THE SIXTH YEAR.

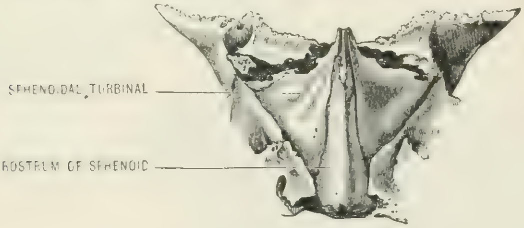


The inferior surface forms the upper boundary of the spheno-palatine foramen, and enters into the formation of the posterior part of the roof of the nasal fossa. The superior surface lies flattened against the under surface of the pre-sphenoid. The base of the cone is in contact with the posterior surface of the lateral mass of the ethmoid.

The deposits of earthy matter from which the sphenoidal turbinals are formed are laid down at the fifth month.

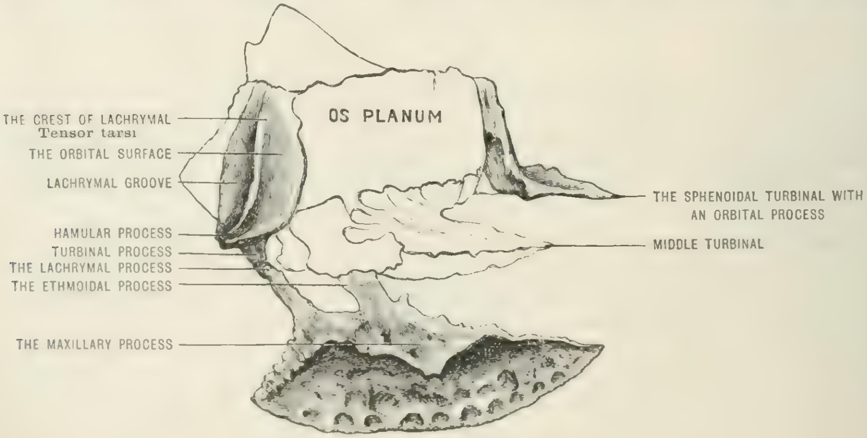
At birth these bones are visible as small triangular ossifications in the perichondrium of the ethmo-vomerine plate near its junction with the pre-sphenoid, and encloses a small recess which becomes a sphenoidal sinus. By the third year the recesses have become completely enclosed and the bones have become hollow cones, the circular orifice representing the base eventually becoming the orifice of the sphenoidal sinus. As the cavity enlarges, the median wall atrophies so that the inner wall of the sinus is formed by the pre-sphenoid. As the turbinal enlarges it ankyloses with adjacent bones. In many skulls it joins the lateral mass of the ethmoid; more frequently it fuses with the pre-sphenoid; less frequently with the palate. After the twelfth year they can rarely be separated from the skull without damage. In many disarticulated skulls they are so broken up that a portion is found on the sphenoid, fragments on the palate bones, and the remainder attached to the ethmoid.

Fig. 63.—The Sphenoidal Turbinals from an Old Skull.


SPHENOIDAL TURBINAL
ROSTRUM OF SPHENOID

Sometimes, even in very old skulls, they are represented by a triangular plate of extreme tenuity on each side of the rostrum of the sphenoid (fig. 63).

Fig. 64.—The Inferior Turbinal, Adult Sphenoidal Turbinal and Lachrymal Bones.


THE CREST OF LACHRYMAL
Tensor tarsi
THE ORBITAL SURFACE
LACHRYMAL GROOVE
HAMULAR PROCESS
TURBINAL PROCESS
THE LACHRYMAL PROCESS
THE ETHMOIDAL PROCESS
THE MAXILLARY PROCESS
OS PLANUM
THE SPHENOIDAL TURBINAL WITH AN ORBITAL PROCESS
MIDDLE TURBINAL

THE INFERIOR TURBINAL

These are a pair of delicate, scroll-like bones, and may be regarded as dismemberments of the lateral masses of the ethmoid, with which they are closely related. Each bone presents two surfaces, two borders, and two extremities.

The **outer surface** is concave, and overhung by the **auricular** or **maxillary process.** The **inner surface** is convex and pitted with depressions. The **superior border** presents from before backwards three processes: the first is called the **lachrymal process,** because it articulates with the turbinal process of the lachrymal bone. The margin of bone at the base of this process comes into relation with the nasal process of the maxilla. The second vertical spiculum is the **ethmoidal process,** which joins the uncinate process of the ethmoid. The third or **maxillary process** is a thin lamella of bone, turned downwards; it overhangs the orifice of the maxillary sinus, and serves to fix the bone firmly to the outer wall of the nasal fossa. The margin posterior to the maxillary process comes into relation with the inferior turbinal crest of the palate bone. The inferior border is rounded and free. It is the thickest part of the bone. The extremities are narrow, the posterior being the more pointed.

Articulations.—The inferior turbinal articulates with the maxilla, lachrymal, palate, and ethmoid.

The inferior turbinal is ossified in cartilage from a single nucleus which appears about the fifth month of intra-uterine life.

At birth it is a relatively large bone, and fills up the lower part of the nasal fossa.

THE LACHRYMAL

The lachrymal bones are extremely thin and delicate, quadrilateral in shape, and situated at the anterior part of the inner wall of the orbit. They are the smallest of the facial bones.

The outer or orbital surface is divided by a vertical ridge into two unequal portions. The anterior smaller portion is deeply grooved to form the **lachrymal sulcus,** which lodges the lachrymal sac and forms the commencement of the lachrymal duct. The portion behind the ridge is smooth, and forms part of the inner wall of the orbit. The ridge gives origin to the *tensor tarsi* muscle, and terminates inferiorly in a hook-like process, the **hamulus,** which curves forwards to articulate with the lachrymal tubercle of the maxilla and completes the superior orifice of the lachrymal canal. The inner surface is in relation with the two anterior cells of the ethmoid (lachrymo-ethmoid), and forms part of the infundibulum. The superior border is short, and articulates with the internal angular process of the frontal. The lower border posterior to the crest joins the inner edge of the orbital plate of the maxilla. The narrow piece, anterior to the ridge, is prolonged downwards to join the lachrymal spine of the inferior turbinal, and is called the **turbinal process.** The anterior border comes into relation with the posterior border of the nasal process of the maxilla. The posterior border articulates with the os planum of the ethmoid.

Articulations.—The lachrymal articulates with the ethmoid, maxilla, frontal and inferior turbinal bones.

Blood-supply.—Its arteries are derived from the infraorbital, the nasal branch of the ophthalmic, and the anterior ethmoidal.

Ossification.—This bone arises in the membrane overlying the cartilage of the fronto-nasal plate. Its mode of ossification is very variable. As a rule it is described as coming from one nucleus. Not unfrequently the hamulus is a separate element. Sometimes the bone is divided horizontally, and a process of the os planum projects between the two halves to join the nasal process of the maxilla. More rarely the bone is represented by a group of detached ossicles resembling Wormian bones.

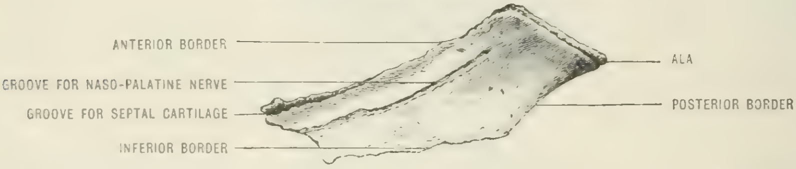
THE VOMER

The vomer is an irregular four-sided plate of bone constituting the lower portion of the nasal septum. It is usually described as resembling a ploughshare in shape. Each lateral surface is covered by the thick mucous membrane of the nasal sinus, and is traversed by a narrow but well-marked groove, which lodges the naso-palatine nerve from the spheno-palatine ganglion; hence it is sometimes called the *naso-palatine groove*.

The superior border of the bone is expanded laterally into two *alæ*. The groove between them lodges the rostrum of the sphenoid, whilst the margin of each ala comes into contact with the sphenoidal process of the palate bone. Between the alæ and the sphenoid a canal exists on each side of the rostrum for blood-vessels. The inferior border is uneven, and is received into the groove formed by the crests of the opposed maxillæ and the palatine bones of each side. The anterior border joins posteriorly the mesethmoid, and in front the triangular (median) nasal cartilage. The posterior border, smooth, rounded, and covered by mucous membrane, serves to separate the posterior nares. The anterior and inferior borders meet each other at the apex of the bone.

Articulations.—The vomer articulates with the sphenoid, palates, ethmoid, and maxillæ, and with the triangular cartilage.

Fig. 65.—The Vomer. (Side view.)



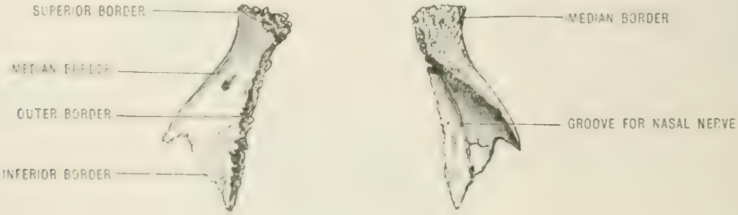
Blood-supply.—Its arteries are derived from the anterior and posterior ethmoidal, the naso-palatine, and the pterygo-palatine arteries, and twigs from the posterior palatines through Stenson's canals.

Ossification.—The vomer is a membrane-bone, and arises from a single centre deposited in the lower border of the perichondrium of the ethmo-vomerine plate as early as the eighth week. From this single centre a lamina of bone extends on each side of the cartilage plate. For many weeks the vomer is a shallow bony trough. Gradually it presses upon and induces absorption of the enclosed cartilage, and by degrees the laminæ fuse, and form a rectangular plate of bone. At birth the vomer presents an expanded lower border, especially in cases of cleft palate.

THE NASAL

These are two oblong bones situated in the middle line at the upper part of the face, and forming the bridge of the nose. Each bone has two surfaces and four borders. The facial surface is concave from above downwards, but convex from side to side. Near its centre is a foramen for the transmission of a small tributary to the facial vein. The posterior or **nasal surface** is concave laterally, and traversed by a longitudinal groove for the nasal branch of the ophthalmic nerve. In life this surface has a covering of mucous membrane. The short superior border is thick and serrated for articulation with the nasal notch of the frontal. The inferior border is thin, and serves for the attachment of the lateral nasal cartilages. Each bone articulates with its fellow by the median border, which is

Fig. 66.—The Left Nasal Bone.



prolonged backwards to form a crest; this crest comes into relation with the nasal spine of the frontal and the anterior border of the mesethmoid. The outer border articulates with the nasal process of the maxilla.

Articulations.—The nasal bone articulates with its fellow, the frontal, maxilla, and ethmoid.

Blood-supply.—Twigs to this bone are furnished by the nasal branch of the ophthalmic, the frontal, the angular, and the anterior ethmoidal arteries.

Ossification.—Each nasal bone is developed from a single earthy nucleus in the membrane overlying the fronto-nasal cartilage. The nucleus is easily seen during the eighth week. The bone by its pressure soon produces absorption of the underlying cartilage. At birth the nasal bones are nearly as wide as they are long, whereas in the adult, the length of the bones is three times greater than the width.

THE MAXILLA

The maxillæ are two hollow irregular cuboidal bones with two prominent processes. They form a large portion of the facial skeleton.

This bone is occupied by a large cavity, the **antrum.** The **body** presents four surfaces. Of these the **facial surface** looks forwards and outwards and presents the following points of interest:—The socket for the canine tooth causes a low elevation, the **canine eminence,** having to its inner side the **incisive fossa,** from which the *depressor alæ nasi* arises. On the outer side of the eminence is the **canine fossa,** which gives origin to the *levator anguli oris.* Above this fossa is the **infraorbital foramen,** through which the terminal branches of the infraorbital nerve and artery emerge. From the ridge above this foramen the *levator labii superioris* arises.

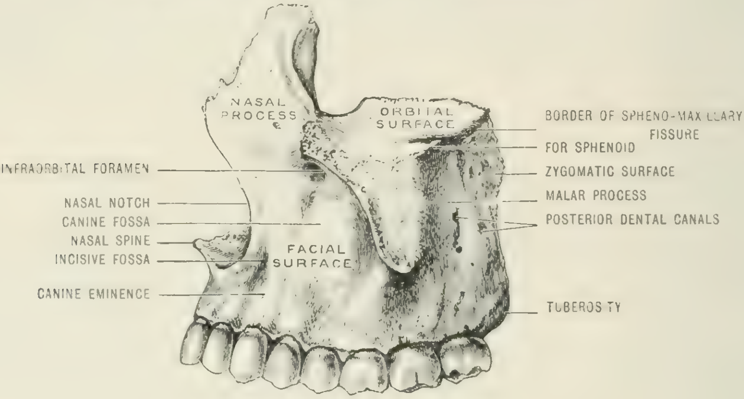
A ridge of bone extending upwards from the socket of the second molar tooth separates the facial from the **zygomatic surface.** Near the middle of the zygomatic surface are the orifices of the canals for the posterior dental nerves and vessels. The posterior inferior angle of this surface is termed the **tuberosity** ; from it a few fibres of the *internal pterygoid* muscle arise. This tuberosity is most prominent after eruption of the wisdom tooth; the rough surface along its inner border is for the tuberosity of the palate bone; the smooth surface immediately above forms the anterior boundary of the spheno-maxillary fossa, and enters into the formation of the descending palatine canal.

The **orbital surface** is irregularly triangular and forms the greater part of the floor of the orbit. Anteriorly it is rounded and forms part of the circumference of the orbit; externally it is rough for suture with the malar bone; the rough surface ends in a backwardly projecting spine which occasionally joins the sphenoid and forms the anterior limit of the spheno-maxillary fissure. The posterior margin, smooth and rounded, forms the inferior limit of the spheno-maxillary fissure. The internal border is nearly straight; quite at the posterior part is a gap for the orbital process of the palate bone; anteriorly it articulates with the os planum of the ethmoid; beyond this it receives the lachrymal bone, and in the anterior angle it is smooth and rounded, forming part of the circumference of the orbital orifice of the **lachrymal duct.**

The orbital surface is traversed by the **infraorbital groove,** which, commencing at the posterior border, deepens as it passes forwards and enters the **infraorbital canal.** This groove receives the second division of the fifth nerve and the infraorbital artery. The infraorbital canal runs under the margin of the orbit and opens on the facial surface. It transmits the infraorbital artery and nerve. At the termination of the groove a smaller canal tunnels the anterior wall of the antrum, and conveys the anterior dental nerves and vessels to the upper incisor, canine, and bicuspid teeth. External to the commencement of the lachrymal duct there is a shallow depression from which the *inferior oblique* takes origin.

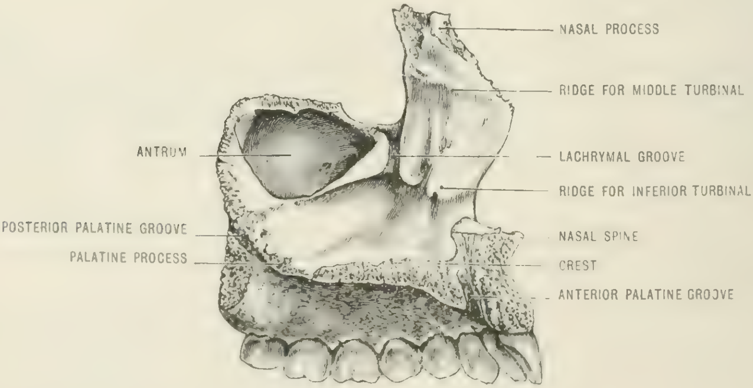
The **internal** or **nasal surface** forms the outer wall of the nasal fossa, and is prolonged inwards to form part of the floor of this fossa. The posterior half of this surface is deficient, and leads by a large irregular aperture into the **antrum** ; below and behind this opening the bone is rough for articulation with the vertical plate of the palate bone. The extreme posterior border receives the tuberosity of the palate bone; the groove in front of it forms part of the posterior palatine canal. Anterior to this surface the bone becomes suddenly smooth; between the smooth and rough portions is the **maxillary fissure** for the reception of the thin maxillary process on the anterior border of the vertical plate of the palate bone. In the angle between this surface and the nasal process is a deep groove converted by the lachrymal and inferior turbinal into the nasal duct. Running backwards from the anterior margin is the **inferior turbinated crest** which articulates with the lowest turbinal bone. The surface above the crest forms part of the **middle meatus,** and the surface below belongs to the **inferior meatus** of the nose, and is directly continuous with the superior surface of the palatine process. Near its anterior border is the orifice of the **anterior palatine canal.**

FIG. 67.—THE LEFT MAXILLA. (Outer view.)


NASAL PROCESS
ORBITAL SURFACE
BORDER OF SPHENO-MAXILLARY FISSURE
FOR SPHENOID
INFRAORBITAL FORAMEN
ZYGOMATIC SURFACE
MALAR PROCESS
NASAL NOTCH
CANINE FOSSA
POSTERIOR DENTAL CANALS
NASAL SPINE
FACIAL SURFACE
INCISIVE FOSSA
CANINE EMINENCE
TUBEROSITY

The **inferior** or **palatine surface** is formed by the palatine process and the alveolar border. The palatine process forms the anterior part of the roof of the mouth. It is concave, rough, and pitted with foramina for vessels. Where it joins the alveolar border a groove (sometimes a canal) exists for the anterior palatine nerve and posterior palatine vessels. When the bones of opposite sides are placed in apposition the **palatine fossa** is formed; running outwards from this to the space between the second incisor and canine tooth, the **maxillo-premaxillary suture** can be detected in young bones. The posterior border articulates with the horizontal process of the palate bone, whilst the median border joins its fellow to form above, a prominent crest upon which the vomer is received.

FIG. 68.—THE LEFT MAXILLA. (Inner view.)

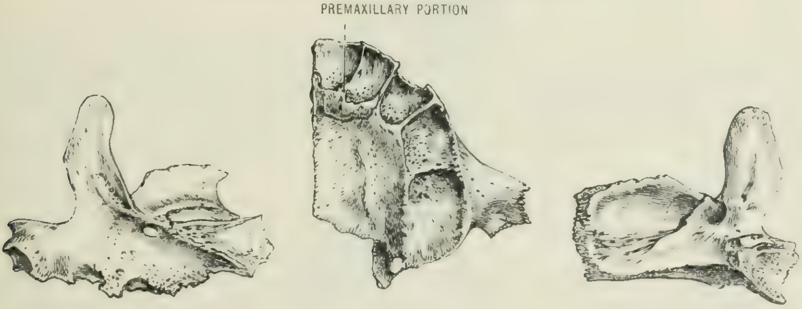

NASAL PROCESS
RIDGE FOR MIDDLE TURBINAL
ANTRUM
LACHRYMAL GROOVE
RIDGE FOR INFERIOR TURBINAL
POSTERIOR PALATINE GROOVE
NASAL SPINE
PALATINE PROCESS
CREST
ANTERIOR PALATINE GROOVE

The **anterior palatine fossa** is situated in the **meso-palatine** suture near its anterior termination. In its typical form the fossa contains four passages: two are small and disposed one behind the other exactly in the suture; these are the **foramina of Scarpa** for the naso-palatine nerves, the left nerve emerging from the anterior foramen. The lateral and larger orifices diverge to open on each side of the crest. They are called **Stenson's canals,** and lodge recesses of the nasal mucous membrane and remnants of Jacobson's organs.

The **alveolar ridge** forms the outer limit of this surface; it is crescentic in shape, spongy in texture, and presents cavities in which teeth are lodged. When the teeth are complete in number, eight cavities are present; of these the pit for the canine tooth is the deepest, those for the molars are the widest and present subdivisions. Along the outer aspect of the alveolar border the *buccinator* arises as far forwards as the first molar tooth.

The **nasal process** is somewhat triangular, rising vertically from the **nasal angle** of the maxilla. Its outer surface gives attachment to the *orbicularis palpebrarum, the tendo oculi*, and the *levator labii superioris alæque nasi*. The internal surface forms one of the lateral boundaries of the nasal fossa. Superiorly it articulates with the frontal; below this is the **superior turbinated crest** for articulation with the middle turbinal. The space between this and the inferior turbinated crest forms part of the **middle meatus.** The anterior border articulates with the nasal bone; the posterior is thick and vertically grooved to form part of the nasal duct. The inner margin of this groove articulates with the lachrymal bone. The point where the outer margin of the groove joins the orbital plate is indicated by the **lachrymal tubercle.**

FIG. 69.—THE MAXILLA AT BIRTH.



Outer view. Inferior view. Inner view.

The **malar process** is rough and triangular, and forms the summit of the ridge of bone separating the facial and zygomatic surfaces. It articulates with the malar bone, and from its inferior angle a few fibres of the *masseter* take origin.

The **antrum** or **maxillary sinus,** as the air-chamber occupying the body of the bone is called, is somewhat pyramidal in shape; the **base** being represented by the nasal or internal surface, and the **apex** corresponding to the malar process. In addition to these it has four walls: the superior is formed by the orbital plate, and the inferior by the alveolar ridge. The anterior wall corresponds to the facial surface of the maxilla, and the posterior is formed by the zygomatic surface. The inner boundary or base presents a very irregular orifice at its posterior part; this is partially filled in by the vertical plate of the palate bone, the uncinate process of the ethmoid, the maxillary process of the inferior turbinal, and a small portion of the lachrymal bone. Even when these bones are *in situ*, the nasal orifice is very irregular in shape, and requires the mucous membrane to form the definite rounded aperture (or apertures, for they are often multiple) known as the **opening of the antrum.** The cavity of the antrum varies considerably in size and shape. In the young, it is small and the walls are thick: as life advances, the antrum enlarges at the expense of its walls, and in old age they are often of extreme tenuity; occasionally the cavity extends into the substance of the malar bone. The floor of the antrum is, as a rule, very uneven, due to prominences corresponding to the roots of the molar teeth. In most cases the bone separating the teeth from the antrum is very thin, and not rarely the roots project uncovered into it. The teeth which come into closest relationship with the antrum are the first and second molars, but the sockets of any of the teeth lodged in the maxilla may, under diseased conditions, communicate with it. Although, as a rule, the cavity of the antrum is single, yet specimens occasionally come to hand in which it is divided by bony septa into chambers, and it is far from uncommon to find it divided into recesses by bony processes. In many maxillæ, the roof of the antrum presents near its anterior aspect what appears to be a thick rib of bone; this is hollow and corresponds to the infraorbital canal.

The most satisfactory method of studying the relation of the bones closing in the base of the antrum is to cut away the outer wall of the cavity (see fig. 80).

Articulations.—The maxilla articulates with its fellow, and with the frontal, nasal, lachrymal, ethmoid, palate, vomer, malar and inferior turbinal bones. Occasionally it articulates with the greater wing, and less frequently with the pterygoid process of the sphenoid bone.

The **muscles** attached to it are mainly those known as muscles of expression:—

Compressor naris.
Orbicularis palpebrarum.
Orbicularis oris.
Levator labii superioris.
Levator labii superioris alæque nasi.
Levator anguli oris.
Inferior oblique.
Depressor alæ nasi.
Buccinator.
Internal pterygoid.
Masseter.

Blood-supply.—The maxilla is a very vascular bone, and its arteries are numerous and large. They are derived from the infraorbital, alveolar, descending palatine, naso-palatine, ethmoidal, frontal, nasal, and facial vessels.

Ossification.—The maxilla arises from four centres which are deposited in membrane.

The various centres may be termed **premaxillary, maxillary, malar,** and **prepalatine.** They arise about the eighth week of embryonic life, and fuse very rapidly.

(*a*) The **premaxillary** nucleus gives rise to that portion of the bone which lodges the incisor teeth. It sends a narrow process upwards which forms part of the outer boundary of the anterior narial aperture. On the palatine aspect it furnishes a spiculum which surrounds the anterior and mesial aspect of Stenson's canal. The posterior limit is indicated up to the end of the first dentition by the maxillo-premaxillary suture. The greater part of this centre is formed in membrane, but the inner part subsequently invades the ethmo-vomerine cartilage.

(*b*) The **maxillary** nucleus forms the nasal process, and the greater part of the body of the maxilla.

(*c*) The **malar** centre gives origin to that portion of the bone lying external to the infraorbital groove.

(*d*) The **prepalatine** centre gives rise to the nasal surface of the maxilla and the palatine process posterior to Stenson's canal. This portion is in shape similar to the palate bone.

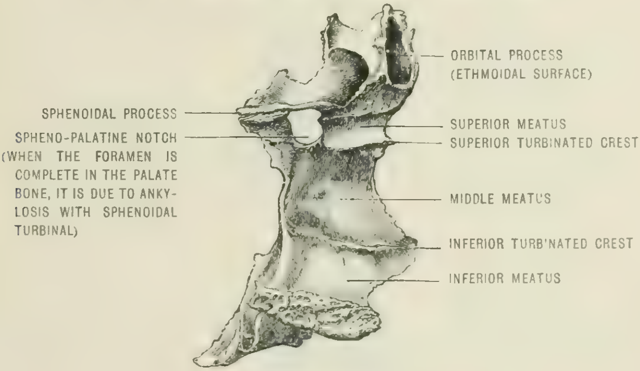
THE PALATE BONE

The palate bone is rectangular in shape, and wedged between the maxilla and the pterygoid processes of the sphenoid. It has a horizontal and a vertical plate, a tuberosity, and two processes.

The **horizontal plate** is smaller than the vertical; it is quadrilateral in shape. The upper surface forms the posterior part of the floor of the nasal fossa; the inferior surface completes the hard palate posteriorly, and presents near its posterior border a transverse ridge, which gives attachment to the *tensor palati* muscle. The anterior border is rough for articulation with the palatine process of the maxilla. The posterior border is free, curved, and sharp; it gives attachment to the soft palate. The inner border is broad, and rough for articulation with its fellow. When the palate bones are in apposition, these borders form a ridge continuing the crest formed by the palatine processes of the maxillæ; this crest receives the inferior border of the vomer. The posterior extremity of the crest forms the posterior nasal spine, from which the *azygos uvulæ* arises.

The **vertical plate** is thin; of its two surfaces, the outer is rough for articulation with the maxilla, except a small portion near the middle close to the anterior border where it looks into the antrum, and a small triangular surface at the upper end where it forms part of the spheno-maxillary fossa. Towards the posterior border there is a vertical groove, which forms with the maxilla the posterior palatine canal; it transmits the descending palatine nerves and vessels. The canal may be more or less complete in the palate bone. The internal surface has two transverse ridges separating three shallow depressions. Of these depressions the lower forms part of the inferior meatus of the nose, and the limiting ridge or crest articulates with the inferior turbinal. Above this is the depression for part of the middle meatus; the ridge above is for the second turbinal. The upper groove is narrower and deeper than the lower two, and forms a large part of the superior meatus. The ridges are known as the **turbinated crests.** The borders of the vertical plate are terminated by irregular prominences, which enter into complex union with surrounding bones.

FIG. 70.—PALATE (LEFT) BONE. (Inner view.)


ORBITAL PROCESS (ETHMOIDAL SURFACE)
SPHENOIDAL PROCESS
SPHENO-PALATINE NOTCH (WHEN THE FORAMEN IS COMPLETE IN THE PALATE BONE, IT IS DUE TO ANKYLOSIS WITH SPHENOIDAL TURBINAL)
SUPERIOR MEATUS
SUPERIOR TURBINATED CREST
MIDDLE MEATUS
INFERIOR TURBINATED CREST
INFERIOR MEATUS

The **posterior border** is vertical, and comes into relation with the anterior border of the internal pterygoid process; below, it terminates in a prominent **tuberosity.** This presents three grooves or flutes: the inner receives the internal pterygoid, the outer the external pterygoid process, while the middle groove completes the **pterygoid fossa,** and affords attachment to a few fibres of the *internal pterygoid* muscle; the *superior constrictor of the pharynx* also arises from this process. The tuberosity is tunnelled by canals: to the nasal side are the **accessory palatine canals ;** near its junction with the horizontal plate is the orifice of the **posterior palatine canal ;** and outside this occasionally may be found the minute **external palatine canals** (fig. 81).

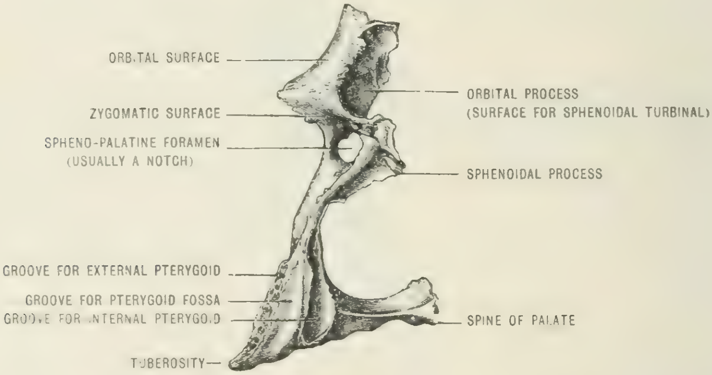
The **sphenoidal process,** which is a process of variable shape, surmounts the posterior border; it has three surfaces and two borders. The superior surface comes into apposition with the sphenoidal turbinal bone, and forms part of the **pterygo-palatine canal.** The internal surface forms part of the outer wall of the nasal fossa, and is prolonged on to the roof, and comes in contact with the ala of the vomer. The outer surface is subdivided by a thin lip into an anterior smooth portion for the spheno-maxillary fossa, and a posterior rough part for the base of the internal pterygoid plate. Of the borders, the posterior is thin and articulates with the internal pterygoid plate; the anterior border forms the posterior boundary of the **spheno-palatine foramen.**

The **anterior border** of the vertical plate is thin, sharp, and presents near the middle the **maxillary process,** which is received into the maxillary fissure of the maxilla near the lower border of the opening of the antrum.

Superiorly this border is terminated by the **orbital process.** This process presents five surfaces; of these, three are articular. The posterior surface joins the walls of the sphenoidal turbinal bone, its air-cells extending occasionally into this part of the palate bone. In the same way the posterior ethmoidal cells extend into the inner surface of the orbital process, where they articulate with the lateral mass. The anterior surface is a continuation of the outer aspect of the vertical plate, and rests upon the maxilla. Of the two non-articular surfaces, the one directed upwards and outwards is slightly concave, and forms part of the floor of the orbit at its junction with the inner wall. The outer smooth surface looks directly into the zygomatic fossa, extends into the spheno-maxillary fossa, and forms the anterior boundary of the spheno-palatine foramen. These surfaces are often conveniently named according to the bones with which they articulate, or the fossæ which they help to form: thus, the anterior or **maxillary**; internal or **ethmoidal**; posterior or **sphenoidal**; superior or **orbital**; external or **zygomatic.**

Between the orbital and sphenoidal processes is the **spheno-palatine notch,** which is converted by the sphenoidal turbinal into a complete foramen. Occasionally it is complete in the palate bone. It transmits the spheno-palatine nerve and artery; the foramen opens into the back part of the nasal fossa, close to its roof. When the spheno-palatine foramen is complete in the palate bone, it is often due to ankylosis between the palate and the sphenoidal turbinal; the latter, being extremely fragile, easily breaks during the process of disarticulation.

FIG. 71.—PALATE BONE. (Posterior view.)



Articulations.—The palate bone articulates with its fellow, the sphenoid, maxilla, vomer, sphenoidal turbinal, inferior turbinal, and ethmoid bones. As the surfaces and lines of union of the orbital and sphenoidal processes are somewhat intricate, the student should, when studying this bone, refer to the following figures. The orbital and zygomatic surfaces are shown in fig. 80. The relation of the sphenoidal process to the nasal fossa in fig. 61. The relations of the pterygoid processes to the tuberosity of the palate are shown in fig. 81. With the help of these drawings the student will be able to understand the position of this bone, which assists in forming the boundary of the following cavities: viz. the nasal, orbital, spheno-maxillary, and antral; and the ethmoidal cells.

The **muscles** attached to it are:—

Internal pterygoid.	Tensor palati.	Azygos uvulæ.
	Superior constrictor of pharynx.	

Blood-supply.—Its arteries are derived from the descending palatine, the spheno-palatine, and pterygo-palatine.

Ossification.—The palate bone arises from one nucleus, which is deposited in membrane, and appears about the eighth week of embryonic life. The spot where the earthy matter is first seen ultimately becomes the angle where the vertical and horizontal plates join. At birth the two plates are nearly equal, but as the nasal sinuses increase in height the vertical plate is lengthened, until it becomes twice the length of the horizontal plate.

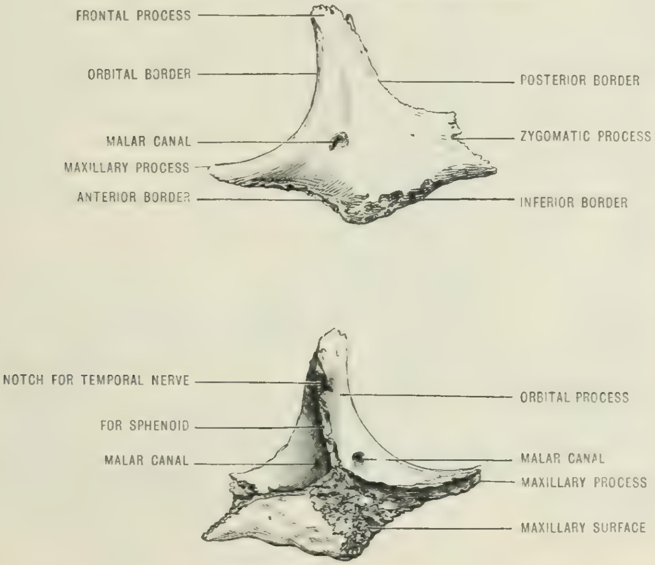
THE MALAR

The malar bone, somewhat quadrilateral in shape, is situated at the outer and upper part of the side of the face, and forms the prominence known as the cheek.

Each bone has a convex external surface, presenting near the centre one or two minute orifices for the transmission of the malar nerves and arteries. This surface is largely covered by the *orbicularis palpebrarum*, and gives origin to the *zygomaticus major* and *minor*.

The internal surface is concave, and abruptly excluded from the orbit by a prominent ledge of bone, the **orbital process**, which forms the anterior boundary of the temporal fossa. A large part of this surface is rough for articulation with the malar process of the maxilla. The orbital process of the malar is at right angles with the external surface, and presents the orbital orifice of the malar canal; this canal is usually single, but it may bifurcate as it traverses the bone, one branch emerging on the external, the other on the internal surface. The thin edge of this process articulates inferiorly with the orbital plate of the maxilla, and ends in a point known as the **maxillary process**. The superior portion articulates with the malar crest on the external surface of the greater wing of the sphenoid; in the suture between these bones a notch (sometimes a foramen) exists for the temporal branch of the fifth nerve. When the orbital surface is large, it excludes the sphenoidal wing from articulation with the maxilla at the anterior extremity of the spheno-maxillary fissure. When this is the case, the border presents near its middle a short non-serrated margin.

Fig. 72.—The Left Malar Bone.



The malar bone presents superiorly the **frontal process**, which articulates with the external angular process of the frontal bone. The **maxillary process** articulates with the maxilla, and occasionally forms the superior segment of the infra-orbital foramen. The **zygomatic process** is directed backwards, and is serrated mainly on its inner aspect for articulation with the zygoma.

Of the four borders, the **orbital** is the longest, and extends from the frontal to the maxillary process. It is thick, rounded, and forms the anterior third of the outer and a large portion of the lower wall and inferior circumference of the orbit. The **inferior** is continuous with the zygoma, and gives origin to the anterior fibres of the *masseter*. The **anterior** border is in relation with the maxilla, and near the margin of the orbit gives origin to a portion of the *levator labii superioris*. The **posterior** border extends from the frontal to the zygomatic process, and presents a double curve; it gives attachment to the temporal fascia. This border is directly continuous below with the upper border of the zygoma, and above with the temporal ridge.

Articulations.—The malar articulates with the maxilla, frontal, sphenoid, and temporal bones.

Blood-supply.—The arteries of the malar are derived from the infraorbital, lachrymal branches of the ophthalmic, transverse facial, and deep temporal arteries.

The **muscles** connected with it are:—

Zygomaticus major.
Levator labii superioris.
Zygomaticus minor.
Masseter.

Ossification.—The malar is a membrane-bone, and arises from two and occasionally three centres, which appear in the eighth week of embryonic life, and grow with astonishing rapidity: the bone quickly attains a relatively large size.

Occasionally the two primary nuclei fail to coalesce, and the bone is represented in the adult by two portions separated by a horizontal suture. Such bipartite malars have been observed in skulls obtained from at least a dozen different races of men. Bipartite malars have been seen with the suture vertical. That the bone may arise from three centres is shown by the fact that tripartite malars have been observed.

At birth the maxillary process reaches as far forwards as the outer border of the infraorbital canal; subsequently it may send a process over the canal.

THE APPENDICULAR ELEMENTS OF THE SKULL

The bones which form this group are the mandible (lower jaw), malleus, incus, stapes, hyoid, the styloid process of the temporal bone, and the internal pterygoid process of the sphenoid.

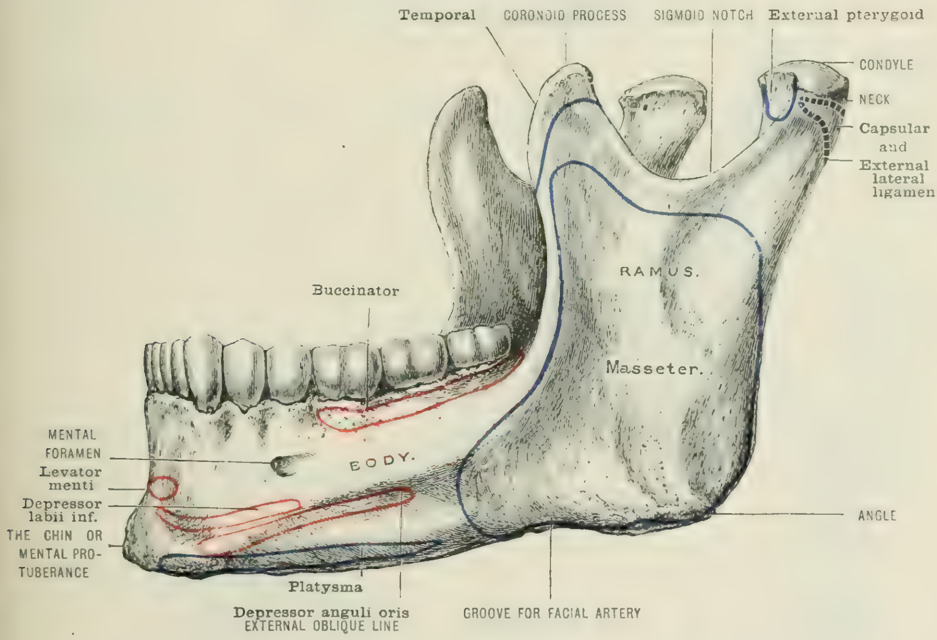
THE MANDIBLE OR LOWER JAW

The **mandible** (*lower jaw* or *inferior maxilla*) is in shape like a horseshoe; it consists of a horizontal portion or body, and two vertical portions or rami.

The **body** consists of a right and a left half, meeting in the middle line to form the symphysis. Each half presents two surfaces and two borders. The **external surface** is smooth and generally convex, and presents the following points of interest:—The **symphysis** ends inferiorly in a triangular surface which forms the **chin.** Near the symphysis is the **incisive fossa,** from which the *levator menti* arises; external to this is the **mental foramen** through which the mental nerve and artery issue. This foramen is in a line with the second bicuspid tooth. Extending backwards and upwards from the mental protuberance, so as to become continuous with the anterior border of the coronoid process, is the **external oblique line**; along its upper border the *depressor labii inferioris* and *depressor anguli oris* arise. The **internal** surface presents, at a point corresponding to the symphysis, two pairs of **genial tubercles.** The upper pair give origin to the *genio-hyo-glossi*, and the lower pair afford insertion to the *genio-hyoid* muscles. The tubercles occasionally form a single, median, irregularly shaped eminence. By the side of the genial tubercles there is a shallow smooth depression, the **sublingual fossa**; below this is the **digastric fossa** for the insertion of the anterior belly of the digastric muscle. Posterior to the genial tubercles, the **internal oblique line** (mylohyoid ridge) commences and extends backwards, becoming more and more prominent as it approaches the alveolar border. The *mylo-hyoid* muscle arises along the whole length of this ridge. At the posterior part the *superior constrictor* takes origin, and the pterygo-maxillary ligament is attached to its posterior extremity. Below the internal oblique line is the **submaxillary fossa,** which is in relation with the submaxillary gland.

The inferior border of the body of the mandible is smooth and rounded: in the anterior part of its extent it gives attachment to the platysma; near its junction with the ramus there is a groove for the facial artery. The superior border is composed of spongy bone, and is named the alveolar process; it presents sockets or alveoli for eight teeth. From the external surface of the alveolar process, as far forwards as the first molar tooth, the *buccinator* muscle takes origin.

FIG. 73.—THE MANDIBLE. (Outer view.)


Temporal
CORONOID PROCESS
SIGMOID NOTCH
External pterygoid
CONDYLE
NECK
Capsular and External lateral ligament
RAMUS.
Buccinator
Masseter.
MENTAL FORAMEN
Levator menti
Depressor labii inf.
THE CHIN OR MENTAL PROTUBERANCE
BODY.
ANGLE
Platysma
Depressor anguli oris
EXTERNAL OBLIQUE LINE
GROOVE FOR FACIAL ARTERY

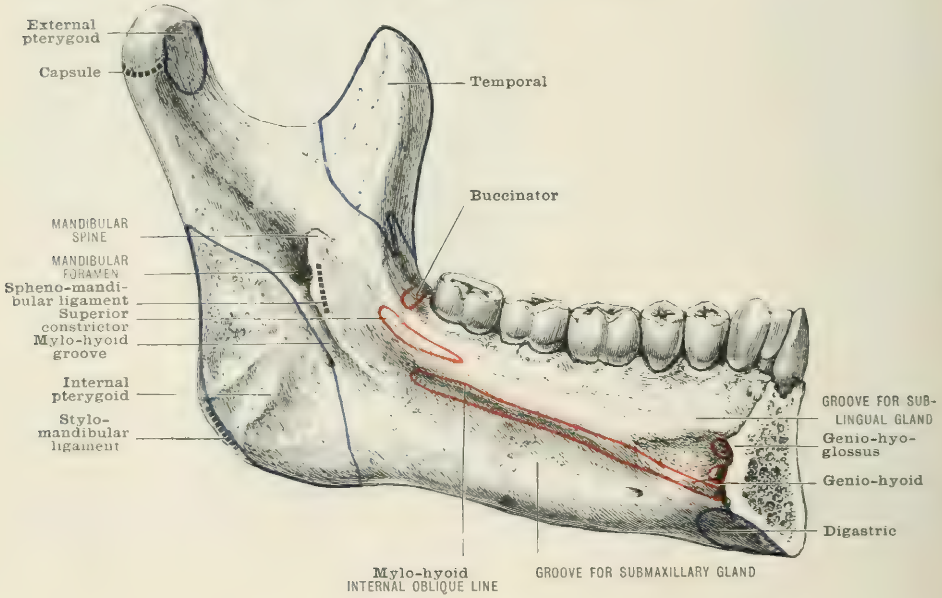
The **ramus** is quadrilateral in shape. It has two surfaces, four borders, and two processes. The external surface is for the insertion of the *masseter* muscle. The internal surface presents near its middle the **mandibular** (inferior dental) **foramen** which leads into the **mandibular** (inferior dental) **canal** which traverses the body of the bone and emerges at the mental foramen. This canal presents a series of fine apertures above, through which filaments of the mandibular nerve and artery pass to the teeth. In its posterior two-thirds, the canal is nearer the internal, in its anterior third, it is nearer the external surface of the mandible. The posterior orifice of the canal is surmounted by the **mandibular spine** to which the spheno-mandibular ligament is attached. Running obliquely downwards behind this spine is the **mylo-hyoid groove,** which lodges the mylo-hyoid nerve and artery. In the embryo, Meckel's cartilage also occupies the groove. The triangular rough space behind this groove is for the insertion of the *internal pterygoid* muscle.

The inferior border of the ramus is thick, rounded, and continuous with the lower border of the body of the bone. The posterior border is rounded: to its lower part the stylo-mandibular ligament is attached. This border is surmounted by the **condyle,** which is connected with the ramus by a somewhat constricted portion, the **neck.**

The **condyle** is oval in shape, with its long axis transverse to the upper border of the ramus, but oblique with regard to the median axis of the skull, so that the outer is more anterior than the inner angle, and presents the **condyloid tubercle** for the external lateral ligament of the temporo-mandibular articulation. The convex surface of the condyle is covered with cartilage and rests in the glenoid fossa: the **neck** is flattened in front and presents a pit, for the insertion of a portion of the *external pterygoid* muscle. The superior border of the ramus is known as the **sigmoid notch**; it is terminated anteriorly by the **coronoid** process. This is a pointed process with two borders and two surfaces; the inner surface presents a ridge, commencing at the tip, and becoming continuous with the inner edge of the alveolus. To this ridge, to the area of bone in front of it and the tip of the coronoid process, the *temporal muscle* is inserted; its outer surface affords attachment to the *masseter* and a few fibres of the *temporal.* The anterior border of the ramus is continuous with the external oblique line on the body of the bone.

Blood-supply.—The mandible is very vascular, and receives a large supply from the mandibular branch of the internal maxillary artery. This constitutes its main supply. It receives twigs also from the facial artery.

FIG. 74.—THE MANDIBLE. (Inner view.)


External pterygoid
Capsule
Temporal
Buccinator
MANDIBULAR SPINE
MANDIBULAR FORAMEN
Spheno-mandibular ligament
Superior constrictor
Mylo-hyoid groove
Internal pterygoid
Stylo-mandibular ligament
GROOVE FOR SUB-LINGUAL GLAND
Genio-hyo-glossus
Genio-hyoid
Digastric
Mylo-hyoid
INTERNAL OBLIQUE LINE
GROOVE FOR SUBMAXILLARY GLAND

It gives attachment to the following **muscles** :—

Buccinator.
Depressor labii inferioris.
Depressor anguli oris.
Levator menti.
Genio-hyo-glossus.
Superior constrictor of pharynx.
Masseter.
Internal pterygoid.
External pterygoid.
Platysma myoides.
Genio-hyoid.
Mylo-hyoid.
Digastric.
Temporal.
Orbicularis oris.

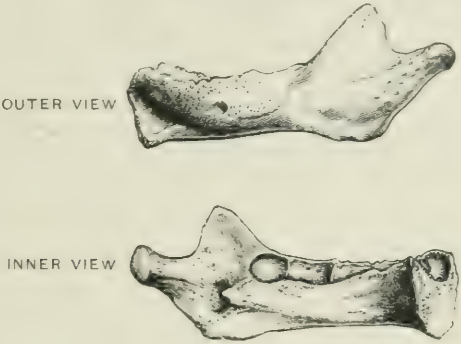
Ossification.—The mandible has six points of ossification for each lateral half. All these, with the exception of one, are deposited in membrane. The nuclei are deposited very early (between the sixth and eighth week), and fuse so rapidly that observations on the development of this bone are unusually difficult.

Its six centres are mainly named according to their position.

The mento-Meckelian.—This is deposited in the distal end of Meckel's (mandibular) cartilage, and gives rise to that portion of the bone between the symphysis and the mental foramen.

The dentary.—This forms the lower border and outer plate, and supports the teeth, hence its name.

FIG. 75.—THE MANDIBLE AT BIRTH.



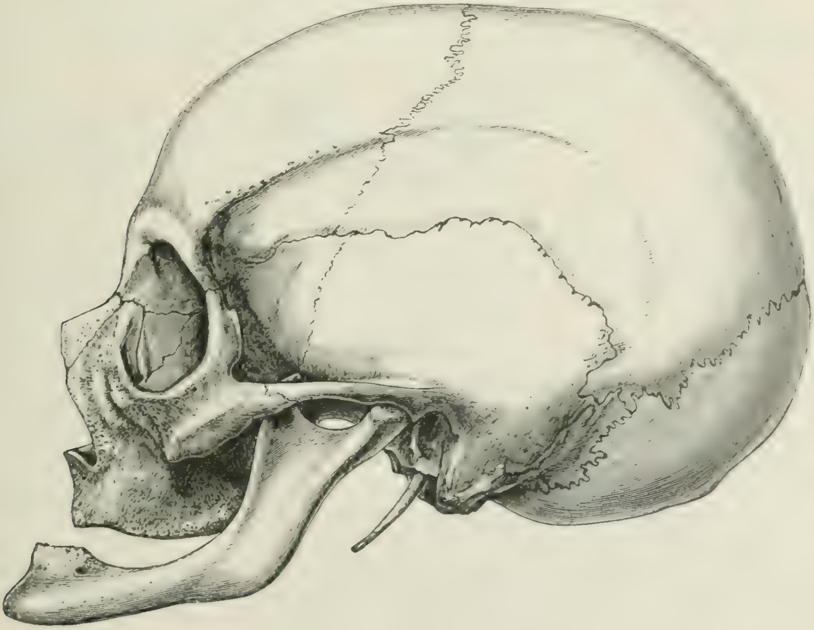
The coronoid.—This gives rise to the process of that name.

The condyloid.—This forms the condyle and adjacent portion of the neck of the bone.

The angular.—This gives rise to the angle of the bone.

The splenial.—This centre appears three weeks later than the portions already mentioned. It forms the inner plate of the mandible from near the symphysis to the mandibular foramen. The mandibular spine represents the posterior extremity of the splenial. Its line of junction with the dentary is indicated in the adult bone by the mylo-hyoid groove.

FIG. 76.—THE SKULL OF AN OLD WOMAN EIGHTY-THREE YEARS OLD, TO SHOW THE CHANGES IN THE MANDIBLE AND MAXILLA.



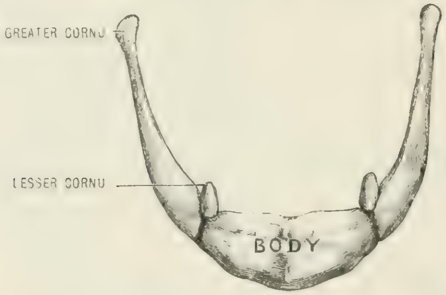
At birth the mandible is represented by two nearly horizontal troughs of bone lodging unerupted teeth. Each half is joined at the symphysis by fibrous tissue. The upper edge of the symphysis and the condyles are nearly on a level. The mandibular nerve lies in a shallow groove between the dentary and splenial plates.

During the first year the two halves ankylose, union taking place from below upwards, but the ankylosis is not complete until the second year. After the first dentition, the ramus forms with the body of the mandible an angle of about 140°, and the mental foramen is situated midway between the upper and lower borders of the bone opposite the second milk-molar. In the adult, the angle formed by the ramus and body is nearly a right angle, and the mental foramen is opposite the second bicuspid, so that its relative position remains unaltered after the first dentition. In old age, after the fall of the teeth, the alveolar margin is absorbed, the angle formed by the ramus and body becomes obtuse, and the mental foramen approaches the alveolar margin. In a young and vigorous adult the mandible is, with the exception of the petrosal, the densest bone in the skeleton, and resists decay longest; in old age it becomes exceedingly porous, and often so soft that it may be broken easily.

THE HYOID, THE STYLOID PROCESS, AND THE EAR-BONES

The **hyoid or lingual bone** consists of a body and four processes. The **body** (basi-hyal) forms the central portion of the bone; it is somewhat oblong in shape. Its anterior aspect is convex and divided by a transverse ridge into a superior and an inferior portion. Frequently it presents a median vertical ridge, and at the point where the horizontal and vertical ridges intersect, a tubercle, sometimes measuring four millimetres in length, is formed. The whole of the anterior surface is crowded with the origin and insertions of muscles. The posterior surface is deeply concave.

FIG. 77.—THE HYOID.



The inferior border is free, the superior gives attachment to the thyro-hyoid membrane. Between this membrane and the concavity of the hyoid there is a large bursa. The lateral borders are in relation with the greater cornua, but remain separated from them until late in life.

The **greater cornua** (thyro-hyals) project backwards and upwards. Their upper and lower borders and anterior surfaces are occupied with muscles. Each corner terminates posteriorly in a rounded tubercle, to which the thyro-hyoid ligament is attached.

The **lesser cornua** (cerato-hyals) are small conical pieces of bone occupying the upper part of the suture between the body and the greater cornua. Their tips are continuous with the stylo-hyoid ligaments.

Muscles attached to the hyoid bone :—

Lingualis.
Genio-hyo-glossus.
Middle constrictor.
Sterno-hyoid.
Digastric.
Genio-hyoid.
Thyro-hyoid.
Omo-hyoid.
Mylo-hyoid.
Hyo-glossus.
Hyo-epiglottideus (when present).

Ligaments :—

Thyro-hyoid.
Stylo-hyoid; and the thyro-hyoid membrane.

Blood-supply.—The hyoid receives twigs from the arteries supplying the muscles attached to it, in addition to direct supply from the superior thyroid and lingual arteries.

Ossification.—At the third month the hyoid consists of hyaline cartilage; it is directly continuous with the styloid process. In the fourth month, a nucleus appears on each side of the middle line; they become quickly confluent to form the body of the bone. In the fifth month each greater cornu has a conspicuous nucleus. The centres for the lesser cornua are delayed until the second year.

The greater cornua remain separate from the body until after middle life. The lesser cornua rarely ankylose with the body of the bone. As a rule, they are small and inconspicuous; occasionally they are very long, and are sometimes continuous with the styloid process of their respective sides.

The **styloid process** is a thin cylindrical spike of bone wedged in between the tympanic plate and the petrosal immediately anterior to the stylo-mastoid foramen. It consists of two parts: a tympano-hyal segment which in the adult is hidden behind the tympanic plate, and a free projecting portion of variable length. As a rule it varies from five to fifty millimetres. When short it is hidden by the vaginal process, but it may reach to the hyoid bone. Its base forms the anterior boundary of the stylo-mastoid foramen. The free portion gives origin to the following muscles: The *stylo-pharyngeus* arises from the base posteriorly; the *stylo-hyoid* from the outer aspect near the middle; and the *stylo-glossus* from the front near the tip. The extremity of the process is continuous with the stylo-hyoid ligament. A band of fibrous tissue—the stylo-mandibular ligament—passes from the process below the origin of the stylo-glossus to the angle of the mandible.

Muscles attached to the styloid process :—

Stylo-glossus.
Stylo-hyoid.
Stylo-pharyngeus.

Ligaments :—

Stylo-hyoid.
Stylo-mandibular.

The morphology and development of this process are described on page 90.

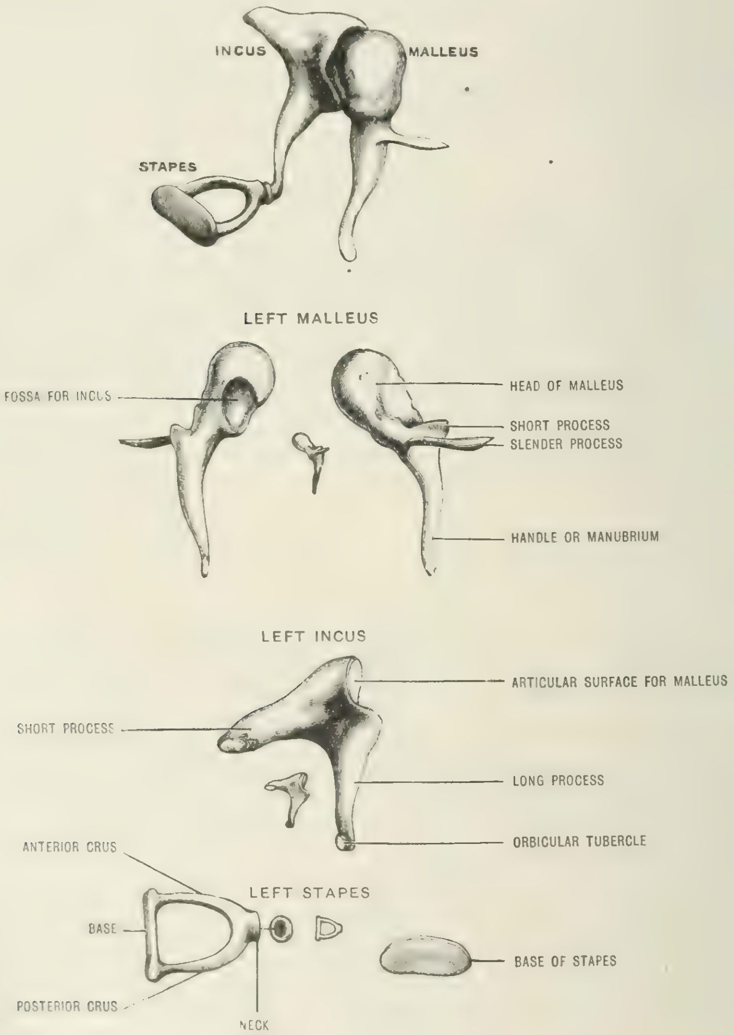
The malleus.—This is the most external of the auditory ossicles, and comes in relation with the tympanic membrane. Its upper portion, or **head,** is lodged in the attic of the tympanum. It is of rounded shape, and presents posteriorly an elliptical depression for articulation with the incus. Below the head is a constricted portion or **neck.** From beneath the neck three processes diverge. The largest is the **handle** or **manubrium,** which is slightly twisted and flattened. It forms an obtuse angle with the head of the bone, and lies between the membrana tympani and the mucous membrane covering its inner surface.

The *tensor tympani* tendon is inserted into the manubrium near its junction with the neck on the inner side. The **slender process** (gracilis or Folian) is a long, slender, delicate spiculum of bone (rarely seen of full length except in the fœtus), projecting nearly at right angles to the anterior aspect of the neck, and extending obliquely downwards. It lies in the Glaserian fissure, and in the adult usually becomes converted into connective tissue, except a small basal stump. The **short process** is a conical projection from the outer aspect of the base of the manubrium. Its apex is connected to the upper part of the tympanic membrane, and its base receives the external ligament of the malleus. The malleus also gives attachment to the suspensory ligament, and to the long anterior ligament of the malleus which was formerly described as the *laxator tympani* muscle.

The incus.—This bone is situated between the malleus externally, and the stapes internally. It presents for examination a body and two processes. The **body** is deeply excavated anteriorly for the reception of the head of the malleus. The **short process** projects backwards, and is connected by means of ligamentous fibres to the posterior wall of the tympanum, near the entrance to the mastoid antrum. The **long process** is slender, and directed downwards and inwards; it lies parallel with the handle of the malleus. On the inner aspect of the distal extremity of this process is the **orbicular tubercle**, connected with the process by a narrow neck. Its free surface articulates with the head of the stapes. The orbicular tubercle is separate in early life.

The **stapes** is the innermost ossicle. It has a **head** directed horizontally outwards, capped at its outer extremity by a disc resembling the head of the radius. The cup-shaped depression receives the orbicular tubercle of the incus. The **base** occupies the fenestra ovalis, and like this opening the inferior border is straight, and the superior curved. The base is connected with the head by means of two **crura**, and a narrow piece of bone called the neck. Of the two crura, the anterior is the shorter and straighter. The crura with the base form a stirrup-shaped arch, of which the inner margin presents a groove for the reception of the membrane which is stretched across the hollow of the stapes. In the early embryo this hollow is traversed by the stapedial artery. The **neck** is very short, and receives on its posterior border the tendon of the *stapedius* muscle.

Fig. 78.—The Bones of the Ear. (Modified from Henle.)


INCUS
MALLEUS
STAPES
LEFT MALLEUS
FOSSA FOR INCUS
HEAD OF MALLEUS
SHORT PROCESS
SLENDER PROCESS
HANDLE OR MANUBRIUM
LEFT INCUS
ARTICULAR SURFACE FOR MALLEUS
SHORT PROCESS
LONG PROCESS
ORBICULAR TUBERCLE
ANTERIOR CRUS
LEFT STAPES
BASE
BASE OF STAPES
POSTERIOR CRUS
NECK

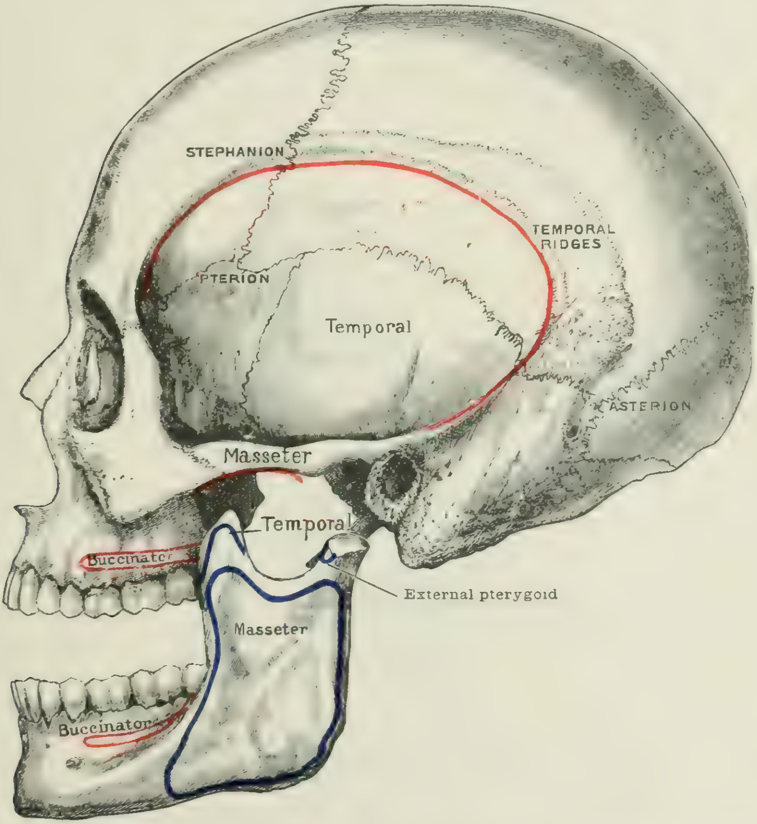
THE EXTERIOR OF THE SKULL

The skull, *when viewed from above*, presents an oval outline; the posterior part is broader than the anterior. The bones seen in this view are the **frontal, parietals,** and the **interparietal** portion of the **occipital.** In a skull of average width the zygomata come into view, but in very broad skulls they are obscured.

The **sutures** of the vertex are:—

The **metopic,** which is, in most skulls, merely a median fissure in the frontal bone just above the **glabella**; occasionally it involves the whole length of the bone. It is due to the persistence of the fissure normally separating the two halves of the bone in the infant.

FIG. 79.—THE SKULL. (Norma lateralis.)



The **sagittal** is situated between the two parietals, and extends from the bregma to the lambda.

The **coronal** lies between the frontal and parietals, and extends from pterion to pterion.

The **lambdoid** is formed by the parietals and interparietal portion of the occipital. It extends from asterion to asterion.

The **occipital** suture is only present when the interparietal exists as a separate element (fig. 35).

The more important regions are:—

The **bregma,** which indicates the situation of the anterior fontanelle, and marks the confluence of the coronal, the sagittal, and, when present, the metopic sutures.

The **lambda,** where the sagittal enters the lambdoid suture: it marks the situation of the posterior fontanelle.

The **obelion**, a little anterior to the lambda, is usually indicated by a median or two lateral foramina. It indicates the spot where the sagittal suture first suffers obliteration.

Viewed from behind, the skull appears irregularly globular; the inferior part of its circumference being somewhat flattened. The limits of the flattened portion are indicated by the mastoid processes.

The centre is occupied by the **occipital protuberance**; this, with the occipital crest and the three pairs of nuchal lines, give to the lower half a rough and uneven appearance. The sutures in this view are the terminations of the sagittal, lambdoidal and, when present, the occipital suture.

The **occipital point** (fig. 90) is the most posterior part of the skull, and is exactly opposite the ophryon.

The **inion** corresponds to the external occipital protuberance.

The *lateral aspect* of the skull is very uneven; it presents three recesses or fossæ. Its irregularity is increased by the zygoma.

The **temporal fossa**, semilunar in shape, is limited above by the superior temporal ridge, and below by the zygoma.

The **temporal ridge** begins at the external angular process of the frontal bone, and curves upwards and backwards to cross the frontal and parietal bones; it then descends along the mastoid portion of the temporal bone to become continuous with the upper border of the zygoma. In many skulls this ridge is double. The lower ridge gives origin to the *temporal* muscle. The upper is the least constant; it diverges from the lower ridge as it approaches the coronal suture. At the middle of the parietal bone the two ridges are often ten millimetres apart. This ridge gives attachment to the temporal fascia. The fossa is almost entirely occupied by the *temporal* muscle.

The **zygomatic fossa** is limited anteriorly by the zygomatic surface of the maxilla; internally by the external pterygoid plate; externally by the zygomatic arch and the ramus of the mandible; and posteriorly by a line drawn from the foramen spinosum to the zygomatic tubercle. The outer surface of the greater wing of the sphenoid internal to the pterygoid ridge and a small piece of the squamosal form part of the upper boundary of the fossa.

The chief objects of interest in this region are:—The **spheno-maxillary** and **pterygo-maxillary fissures**, the **pterygoid ridge** on the sphenoidal wing, the **foramen ovale, foramen spinosum**, and the **articular eminence** of the squamosal.

The **spheno-maxillary fissure** is horizontal in position, and lies between the orbital border of the maxilla and the greater wing of the sphenoid; externally it is completed usually by the malar; frequently the sphenoid will join the maxilla and exclude the malar bone from the fissure; internally it is terminated by the zygomatic surface of the orbital process of the palate bone. Through this fissure the orbital, spheno-maxillary, and zygomatic fossæ communicate. The zygomatic fossa lodges the *temporal*, *external pterygoid*, and *internal pterygoid* muscles.

The **pterygo-maxillary fissure** forms a right angle with the preceding. It is situated between the maxilla and the anterior border of the pterygoid process of the sphenoid. At its lower angle the external pterygoid plate occasionally articulates with the maxilla. The pterygo-maxillary fissure leads from the zygomatic fossa directly into the **spheno-maxillary fossa**, a small space shaped like an inverted pyramid, situated between the maxilla and the roots of the pterygoid processes. The roof of this fossa is formed by the under surface of the greater wing of the sphenoid. The anterior boundaries are a small portion of the zygomatic surface of the maxilla and the orbital process of the palate; posteriorly it has the roots of the pterygoid processes, and the lower part of the orbital surface of the greater wing of the sphenoid; and internally the vertical plate of the palate bone. The apex of the pyramid leads into the **posterior palatine canal**. The inner wall presents the **spheno-palatine foramen** which leads into the nasal fossa. The posterior wall has three openings in the following order, from without inwards, and from above downwards: the **foramen rotundum, Vidian canal**, and **pterygo-palatine canal**. Anteriorly it communicates with the orbit by the **spheno-maxillary fissure**; and externally the **pterygo-maxillary fissure** leads into the zygomatic fossa.

This fossa is mainly of interest on account of its relation to the spheno-palatine (Meckel's) ganglion. The various foramina and canals connected with the fossa serve for the transmission of the nerves connected with this ganglion and the terminal branches of the internal maxillary artery.

In addition to the fossæ, the lateral region presents the glenoid fossa with its articular eminence, the external auditory meatus, the mastoid and styloid processes, and the following sutures:—

The **spheno-parietal,** which lies between the greater wing of the sphenoid and the anterior inferior angle of the parietal.

The **squamous** is formed by the squamosal overlapping the lower border of the parietal.

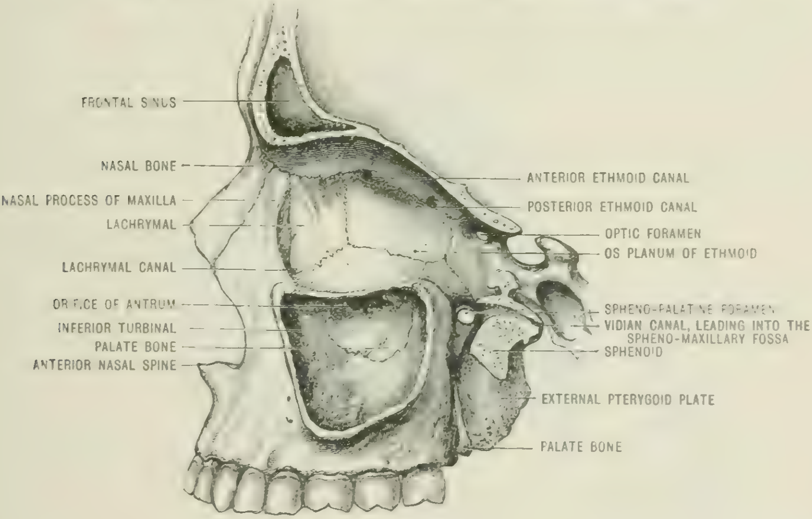
The **parieto-mastoid,** which lies between the posterior inferior angle of the parietal and the mastoid portion of the petrosal.

The **zygomatic** suture is formed by the union of the zygoma with the malar bone.

The **squamo-sphenoidal** is situated between the anterior border of the squamosal and the greater wing of the sphenoid.

The **spheno-malar** suture is formed by the orbital process of the malar and the malar ridge on the greater wing of the sphenoid. Near its middle the suture is perforated by the **spheno-malar foramen,** which allows the temporal branch of the orbital nerve and a branch of the lachrymal artery to escape from the orbit. This foramen in some adult skulls is complete in the malar.

FIG. 80.—A SECTION OF THE SKULL, SHOWING THE INNER WALL OF THE ORBIT, THE INNER WALL OF THE ANTRUM, AND THE SPHENO-MAXILLARY FOSSA.


FRONTAL SINUS
NASAL BONE
NASAL PROCESS OF MAXILLA
LACHRYMAL
LACHRYMAL CANAL
ORIFICE OF ANTRUM
INFERIOR TURBINAL
PALATE BONE
ANTERIOR NASAL SPINE
ANTERIOR ETHMOID CANAL
POSTERIOR ETHMOID CANAL
OPTIC FORAMEN
OS PLANUM OF ETHMOID
SPHENO-PALATINE FORAMEN
VIDIAN CANAL, LEADING INTO THE SPHENO-MAXILLARY FOSSA
SPHENOID
EXTERNAL PTERYGOID PLATE
PALATE BONE

The **fronto-squamosal** is an occasional suture; when it is present, the anterior inferior angle of the parietal is excluded from the greater wing of the sphenoid.

The more important regions are:—

The **pterion,** which marks the situation of the anterior lateral fontanelle, is the meeting-place of the coronal, squamous, spheno-parietal, squamo-sphenoidal, and the fronto-squamosal sutures. Frequently it is occupied in the adult by the **epipteric** ossicle.

The **asterion** indicates the situation of the posterior lateral fontanelle and marks the confluence of the squamosal, parieto-mastoid, lambdoid, the occipito-mastoid, and occasionally the occipital sutures. Sometimes it is occupied by a Wormian bone.

The **stephanion** is the spot where the superior temporal ridge cuts the coronal suture.

The **auricular** point is the centre of the external auditory meatus.

The BASE OF THE SKULL is very irregular, and extends from the incisor teeth to the occipital protuberance. Laterally it is limited by the zygomatic arches. Anteriorly it presents the hard palate. When the skull is inverted, the hard palate stands at a higher level than the rest; it is bounded anteriorly and laterally by the alveolar ridges containing the teeth. The bones appearing in the intermediate space are the premaxillary and palatine portions of the maxillæ, and the horizontal plates of the palate bones. The bone is rough for the attachment of the muco-periosteum. The following points are readily recognised (fig. 81):—

The **meso-palatine suture** commences at the alveolar point, traverses the anterior palatine fossa, and terminates at the posterior nasal spine.

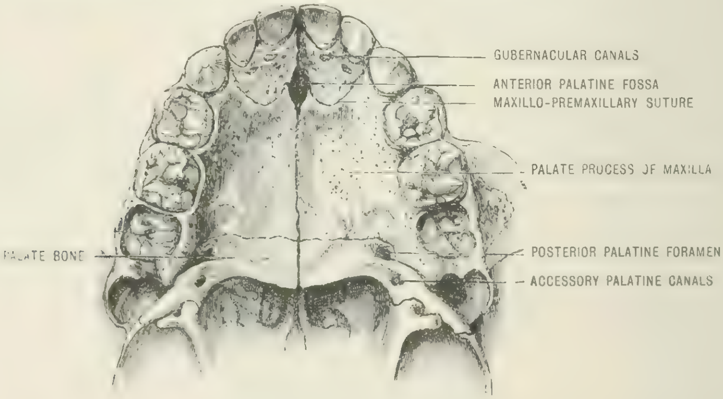
The **transverse palatine suture** between the palate bones and palatine processes of the maxillæ.

In young skulls the **maxillo-premaxillary sutures**, and behind the incisor teeth four small openings known as the **gubernacular canals.**

The anterior palatine fossa containing the termination of four canals: two small orifices, **foramina of Scarpa,** situated one behind the other in the meso-palatine suture; and two larger openings, the **foramina of Stenson.** Scarpa's foramina transmit the naso-palatine nerves; Stenson's are in relation with Jacobson's organs.

At the posterior angles of the hard palate are the **posterior palatine foramina,** through which the posterior palatine vessels and the anterior palatine nerves emerge on to the palate; a thin lip of bone separates them from the **accessory palatine foramina** for the posterior palatine nerves. The accessory foramina are in the tuberosity of the palate bone.

FIG. 81.—HARD PALATE OF A CHILD FIVE YEARS OLD.


GUBERNACULAR CANALS
ANTERIOR PALATINE FOSSA
MAXILLO-PREMAXILLARY SUTURE
PALATE PROCESS OF MAXILLA
PALATE BONE
POSTERIOR PALATINE FORAMEN
ACCESSORY PALATINE CANALS

The **hamular process** of the internal pterygoid plate is the most posterior limit of the hard palate.

At the posterior extremity of each alveolar ridge is the **tuberosity** of the maxilla. Between the tuberosities of the maxilla and the palate bone are a few minute foramina (variable in number and not always present), the **external palatine canals** for the external palatine nerves.

Behind the hard palate are the **posterior nares,** separated from each other by the vomer. Each is bounded externally by the internal pterygoid plate; below by the horizontal plate of the palate bone; above by the under surface of the body of the sphenoid, with the ala of the vomer and a portion of the sphenoidal process of the palate bone.

External to the nares there is on each side a vertical fossa lying between the pterygoid plates. It extends upwards to the under surface of the greater wings of the sphenoid; it is completed anteriorly by the coalescence of the pterygoid plates, and below by the tuberosity of the palate bone. It contains the following points of interest:—

An elongated furrow, the **scaphoid fossa,** for the *tensor palati* muscle and the cartilage of the Eustachian tube.

The general cavity of the **pterygoid fossa** which lodges the *tensor palati* and *internal pterygoid* muscles.

Frequently there is a notch in the external pterygoid plate close beside the foramen ovale.

The posterior termination of the **Vidian canal.**

If a line be drawn across the skull-base from one zygomatic tubercle to the other, it will fall immediately behind the external pterygoid plate and bisect the foramen spinosum on each side. A second transverse line, drawn across the **opisthion** or posterior margin of the foramen magnum, will fall behind the mastoid processes. The space between these imaginary lines may be called the *sub-cranial region;* that behind the second line the *sub-occipital region.* In addition to these there is a lateral space anterior to the first line known as the **zygomatic region.** Each will require separate consideration.

The SUB-CRANIAL REGION is formed by the following bones:—In the centre, the under surface of the bodies of the sphenoid and occipital bones. Laterally, the petrosal, a small piece of the greater wing of the sphenoid and of the squamosal, and part of the occipital. It presents the following points in the middle line for study:—

The **pharyngeal tubercle.**

The **foramen magnum** and the **occipital condyles.** The most anterior point of the foramen is termed the **basion,** and the most posterior point the **opisthion.**

On each side will be seen:—The **anterior condyloid foramen** for the hypoglossal nerve and a meningeal branch of the ascending pharyngeal artery.

The **posterior condyloid fossa** with the posterior condyloid foramen (this foramen is not constant).

The **sphenotic** (middle lacerated) **foramen** and the orifice of the **Vidian canal.**

The **canalis musculo-tubarius** for the *tensor tympani* muscle and Eustachian tube.

The **carotid canal.**

Aqueductus cochleæ, or ductus perilymphaticus.

The **jugular foramen** and **fossa** for the glosso-pharyngeal, vagus, and spinal accessory nerves, the internal jugular vein, and a meningeal branch of the ascending pharyngeal artery.

The **tympanic canaliculus** for Jacobson's nerve. (Tympanic of glosso-pharyngeal.)

The **alar spine** of the sphenoid; this is sometimes fifteen millimetres in length.

The **glenoid fossa** with the **Glaserian fissure.** This lodges the slender process of the malleus, the tympanic twig of the internal maxillary artery. A small passage beside it, the **canal of Huguier,** conducts the chorda tympani nerve from the tympanum.

The **external auditory meatus.**

The **auricular fissure** for the tympanic branch of the vagus.

The **tympanic plate** and vaginal process.

The **styloid process.**

The **stylo-mastoid foramen** for the stylo-mastoid artery and the exit of the facial nerve.

The **mastoid process** with the digastric and occipital grooves.

The SUB-OCCIPITAL REGION presents chiefly muscular ridges. They are the superior, middle, and inferior nuchal lines, with the external occipital protuberance and the external occipital crest. Behind the mastoid process is an opening of variable size, the mastoid foramen; a branch of the occipital artery enters, and a vein from the lateral sinus issues from this foramen.

The ANTERIOR ASPECT of the skull is oval in outline, but presents a very irregular surface. Its upper portion, or forehead, presents the **frontal eminences** and **superciliary ridges.** In the middle line is the prominence formed by the nasal bones, with a deep pyramidal recess, the **orbits,** on each side. Below the nasal bones are the entrances to the **nasal sinuses** and the various recesses connected with them. The teeth form a conspicuous feature in this view of the skull, the outline of which is completed by the mandible.

FIG. 82.—THE SKULL. (Norma basilaris.)

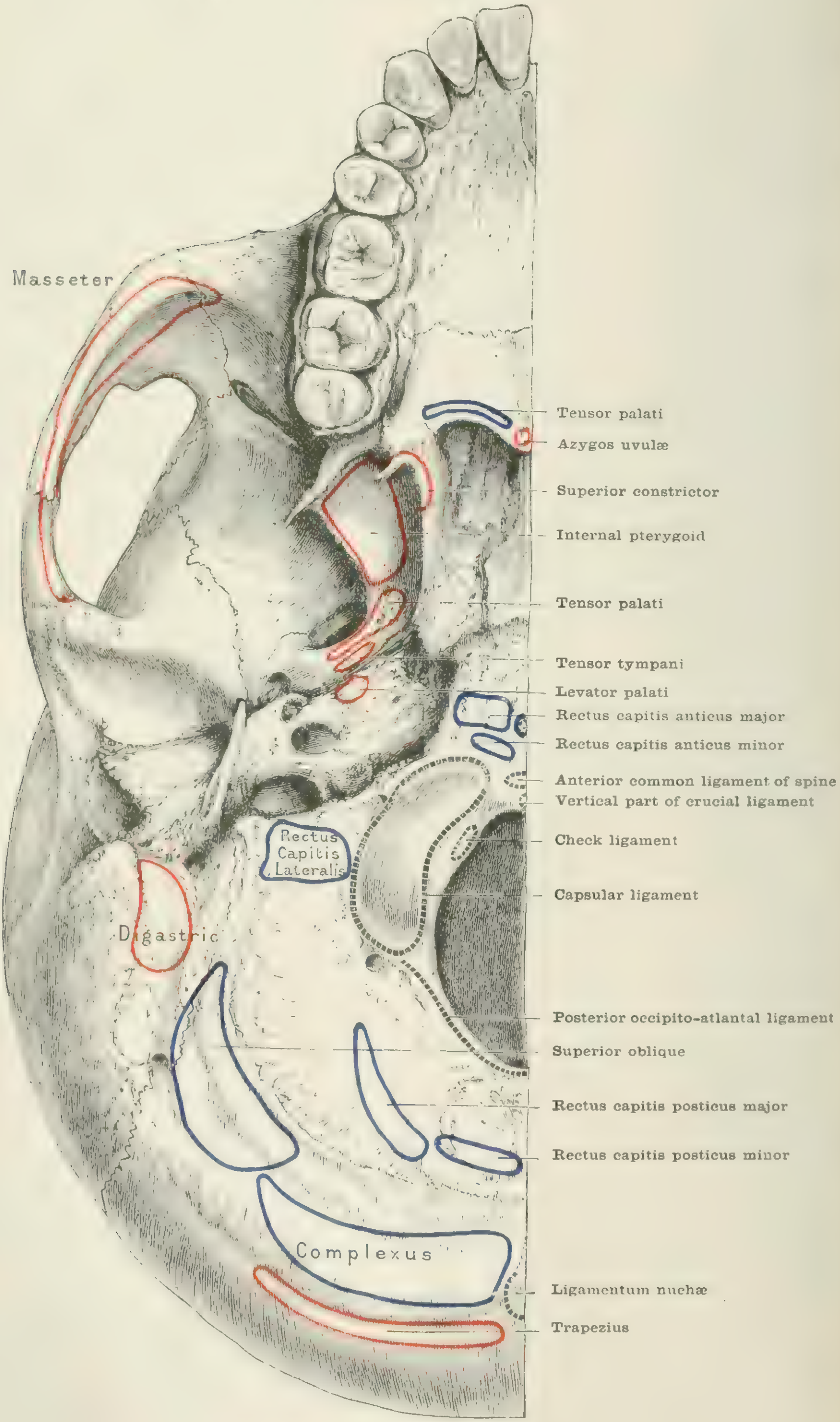
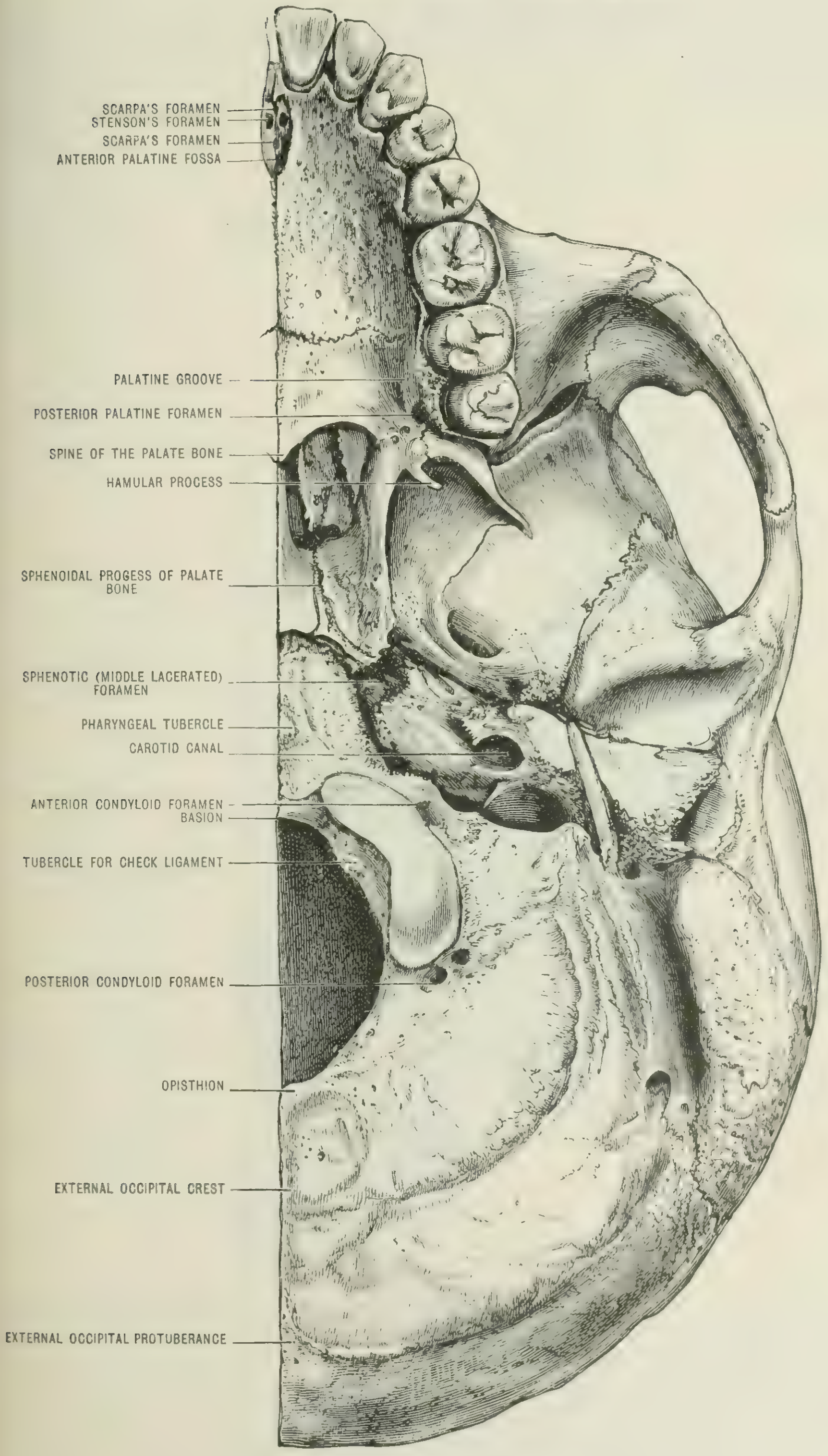

Masseter
Tensor palati
Azygos uvulæ
Superior constrictor
Internal pterygoid
Tensor palati
Tensor tympani
Levator palati
Rectus capitis anticus major
Rectus capitis anticus minor
Anterior common ligament of spine
Vertical part of crucial ligament
Check ligament
Rectus Capitis Lateralis
Capsular ligament
Digastric
Posterior occipito-atlantal ligament
Superior oblique
Rectus capitis posticus major
Rectus capitis posticus minor
Complexus
Ligamentum nuchæ
Trapezius

FIG. 83.—THE SKULL. (Norma basilaris.)

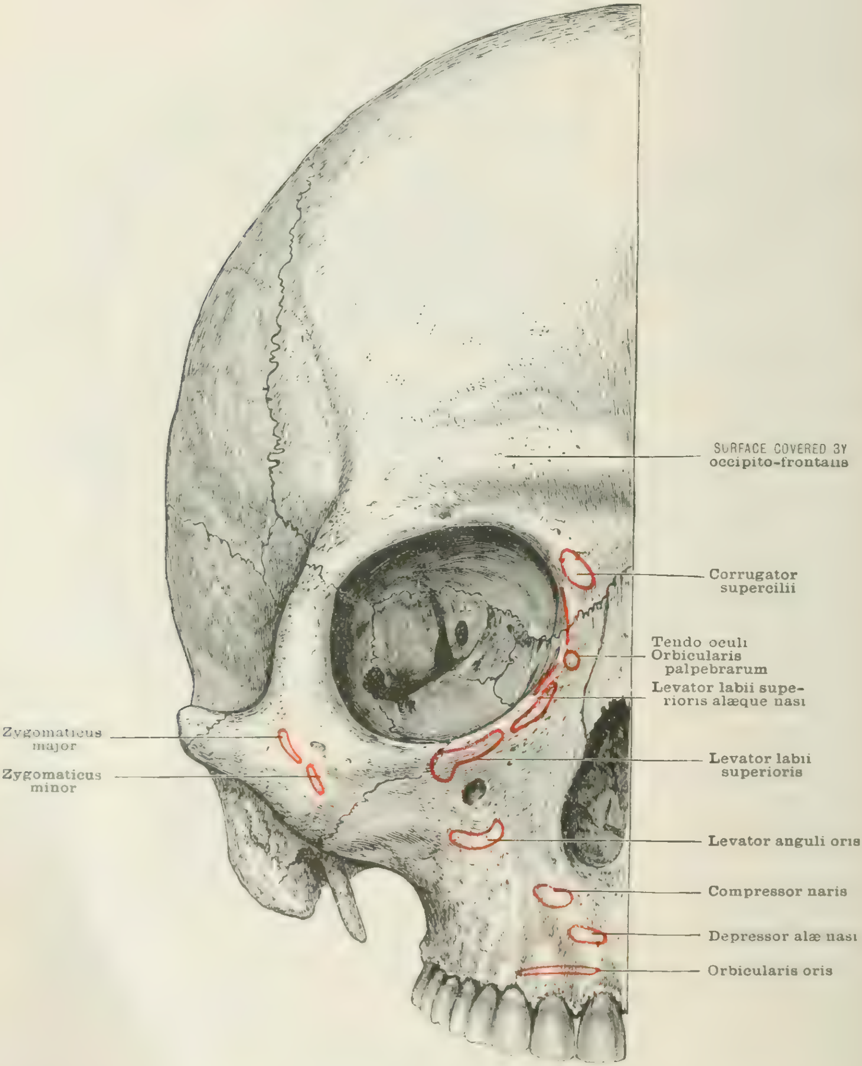

SCARPA'S FORAMEN
STENSON'S FORAMEN
SCARPA'S FORAMEN
ANTERIOR PALATINE FOSSA
PALATINE GROOVE
POSTERIOR PALATINE FORAMEN
SPINE OF THE PALATE BONE
HAMULAR PROCESS
SPHENOIDAL PROCESS OF PALATE BONE
SPHENOTIC (MIDDLE LACERATED) FORAMEN
PHARYNGEAL TUBERCLE
CAROTID CANAL
ANTERIOR CONDYLOID FORAMEN
BASION
TUBERCLE FOR CHECK LIGAMENT
POSTERIOR CONDYLOID FORAMEN
OPISTHION
EXTERNAL OCCIPITAL CREST
EXTERNAL OCCIPITAL PROTUBERANCE

The **bones** visible in this view of the skull are: the frontal, nasals, lachrymals, orbital surfaces of the lesser and the greater wings, and a portion of the body of the sphenoid, the ossa plana of the ethmoid, and the orbital processes of the palate bones, the malars, maxillæ, inferior turbinals, and the mandible.

The **foramina** are: the supraorbital, infraorbital, optic, temporal, and mental; the lachrymal duct; the malar and ethmoidal canals; and the spheno-maxillary and sphenoidal fissures.

The **orbits** are two cavities of pyramidal shape, which lodge the eyeball and its associated muscles, nerves, and vessels. The **apex** of each orbit corresponds to the **optic foramen,** a circular orifice which transmits the optic nerve and ophthalmic artery. The **base** looks forwards and outwards. It is formed by the frontal bone above, the nasal process of the maxilla on the inner side, the malar bone externally, and below by the malar and body of the maxilla. The following points are seen around the base:—The suture between the external angular process of the frontal bone and the malar; the supraorbital notch (sometimes a complete

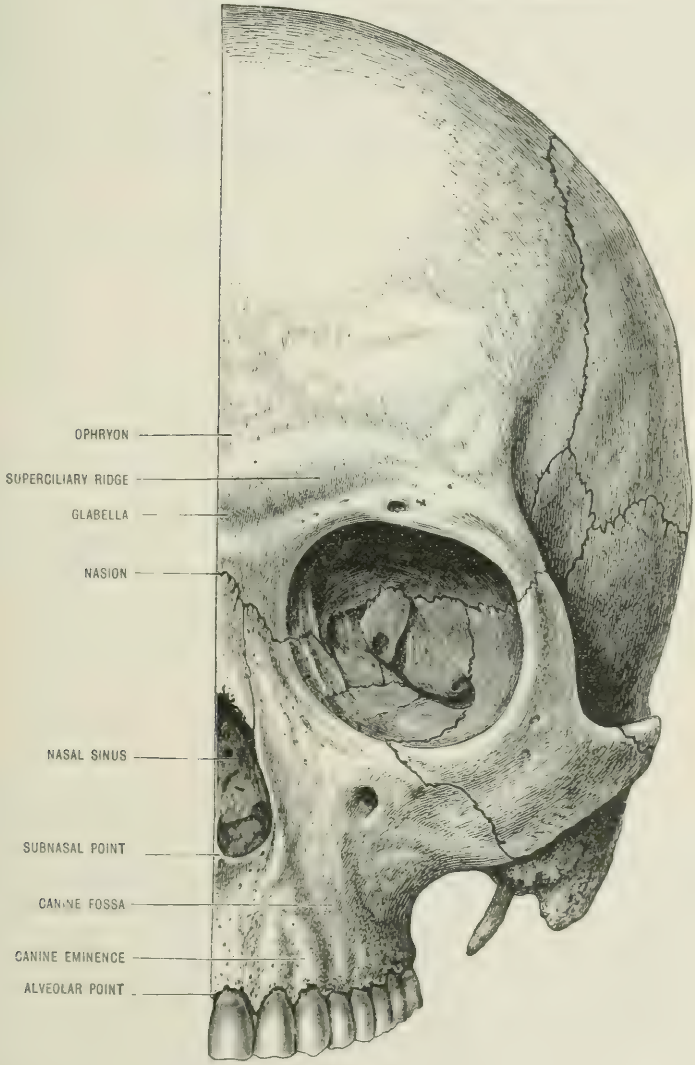
FIG. 84.—THE SKULL. (Norma facialis.)


SURFACE COVERED BY occipito-frontalis
Corrugator supercilii
Tendo oculi
Orbicularis palpebrarum
Levator labii superioris alæque nasi
Levator labii superioris
Levator anguli oris
Compressor naris
Depressor alæ nasi
Orbicularis oris
Zygomaticus major
Zygomaticus minor

foramen); and the suture between the frontal bone and the nasal process of the maxilla; and in the inferior segment of the circumference is the malo-maxillary suture. Occasionally, the infraorbital foramen opens by a narrow fissure into the orbit.

The **roof** of the orbit is formed mainly by the orbital plate of the frontal bone, and completed posteriorly by the lesser wing of the sphenoid. At the outer angle it presents the **lachrymal fossa** for the lachrymal gland, and at the inner angle a depression for the pulley of the *superior oblique* muscle.

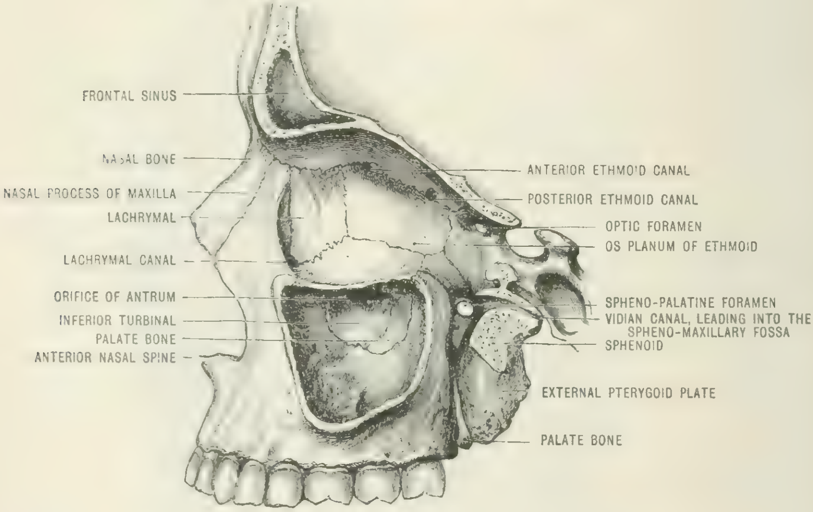
FIG. 85.—THE SKULL. (Norma facialis.)



The **floor** is formed by the orbital plate of the maxilla, the orbital process of the malar, and the orbital process of the palate bone. At its inner angle it presents the lachrymal canal, and near this a depression for the origin of the *inferior oblique* muscle. The floor has a furrow for the infraorbital artery and the second division of the fifth nerve. The furrow terminates anteriorly in the infraorbital canal, through which the infraorbital nerve and artery emerge on the face. Near the commencement of the canal a narrow passage, the anterior dental canal, runs forwards and downwards in the anterior wall of the antrum; it conducts nerves to the incisor and canine teeth.

The **outer wall** is very oblique; it is formed by the orbital surface of the greater wing of the sphenoid, and the malar. Between it and the roof, near the apex, is the **sphenoidal fissure,** by means of which the third, fourth, ophthalmic division of the fifth, and sixth nerves enter the orbit from the cranial cavity. The lower margin of the fissure presents near the middle a small tubercle, from which one head of the *external rectus* muscle arises. Between the outer wall and the floor, near the apex, is the spheno-maxillary fissure, which allows the second division of the fifth nerve to enter the infraorbital groove from the spheno-maxillary fossa. At the anterior margin of the fissure, the sphenoidal wing occasionally articulates with the maxilla, but frequently it is excluded by the malar. In front of the anterior extremity of this fissure is the orbital orifice of the malar canal. Near the outer extremity of the sphenoidal fissure a few small foramina may be seen, especially in old skulls, which allow branches of the middle meningeal artery to creep into the orbit. A vertical fissure, the spheno-malar, traverses the outer wall. It contains the very small spheno-malar foramen, which allows the temporal branch of the orbital nerve to escape from the orbit. This foramen is sometimes confined to the malar bone.

Fig. 86.—The Inner Wall of the Orbit.


FRONTAL SINUS
NASAL BONE
NASAL PROCESS OF MAXILLA
LACHRYMAL
LACHRYMAL CANAL
ORIFICE OF ANTRUM
INFERIOR TURBINAL
PALATE BONE
ANTERIOR NASAL SPINE
ANTERIOR ETHMOID CANAL
POSTERIOR ETHMOID CANAL
OPTIC FORAMEN
OS PLANUM OF ETHMOID
SPHENO-PALATINE FORAMEN
VIDIAN CANAL, LEADING INTO THE SPHENO-MAXILLARY FOSSA
SPHENOID
EXTERNAL PTERYGOID PLATE
PALATE BONE

The **inner wall,** narrow and straight, is formed by the lachrymal, os planum of the ethmoid, and a part of the body of the sphenoid. The ethmoid section of the transverse suture contains the orifices of the **anterior** and **posterior ethmoidal canals**: the former transmits the nasal nerve and anterior ethmoidal artery; the latter the posterior ethmoidal artery, and a branch of the nasal nerve.

Anteriorly is the lachrymal groove, and behind this the crest which gives origin to the *tensor tarsi.* This wall has three vertical sutures: one between the nasal process of the maxilla and the lachrymal, the ethmo-lachrymal, and one between the os planum and body of the sphenoid. Occasionally the sphenoidal turbinal bone appears in the orbit between the os planum of the ethmoid and the body of the sphenoid (fig. 64).

The orbit communicates with the cranial cavity by the optic foramen and sphenoidal fissure; with the nasal fossa by means of the lachrymal duct; with the zygomatic and spheno-maxillary fossæ by way of the spheno-maxillary fissure. In addition to these large openings, the orbit has five other foramina—the infra-orbital, malar, spheno-malar, and the anterior and posterior ethmoidal canals—opening into it or leading from it.

In old skulls the frontal sinuses occasionally extend into that portion of the horizontal plate of the frontal bone which forms the roof of the orbit.

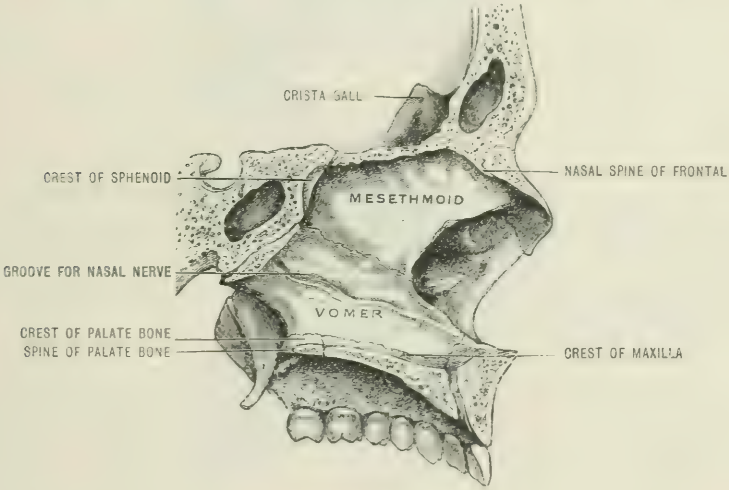
The following **muscles** arise within the **orbit**:—the *four recti*, the *superior oblique*, and *levator palpebræ superioris*, near the apex; the *inferior oblique* on the floor of the orbit external to the lachrymal canal; and the *tensor tarsi* from the lachrymal crest. The margins of the spheno-maxillary fissure give attachment to the *orbitalis* muscle (see section on the Eye).

The **nasal fossæ** or **sinuses** are two irregular cavities situated on each side of a median vertical septum, extending from the anterior part of the skull-base to the superior surface of the hard palate. They are somewhat oblong in section, but are narrower above than below.

Each fossa presents a roof, floor, inner and outer wall, and opens in front by the anterior naris, and communicates behind with the pharynx by the posterior naris.

The **roof** resembles that of a house with two sloping edges and an intermediate level portion. The anterior slope is formed by the posterior surface of the nasal bone and the nasal spine of the frontal. The horizontal portion corresponds to the cribriform plate of the ethmoid and the sphenoidal turbinal. The posterior slope is formed by the inferior surface of the body of the sphenoid, an ala of the vomer, and a small portion of the sphenoidal process of each palate bone. The sphenoidal sinus opens at the upper and back part of the roof into the spheno-ethmoidal recess or superior meatus of the nose.

FIG. 87.—SECTION THROUGH THE NASAL FOSSA TO SHOW THE SEPTUM. LEFT HALF, WITH SEPTUM LOOKING TOWARDS RIGHT NASAL FOSSA.



The **floor** is wider than the roof, concave from side to side, and has a slight backward slope. It is formed mainly by the palatine process of the maxilla, and completed posteriorly by the horizontal plate of the palate bone. Near its anterior part, close beside the septum, is the **anterior palatine canal.**

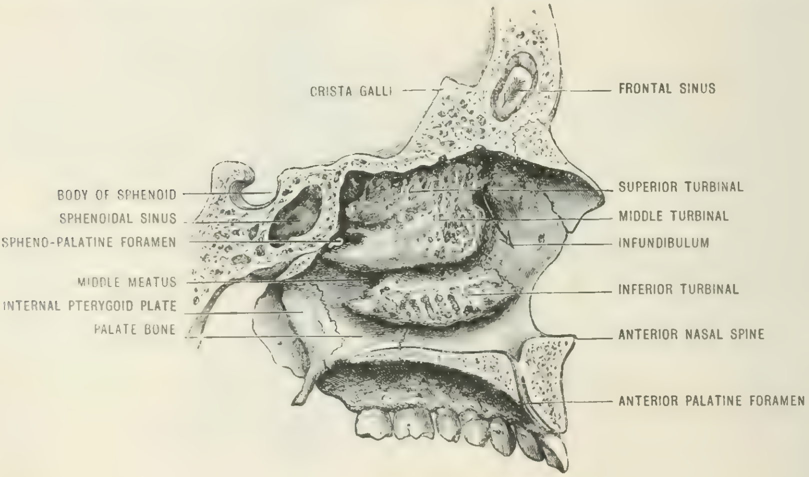
The **septum,** or inner wall, is formed by the crest of the sphenoid, the crest of the nasal bones, nasal spine of frontal, the mesethmoid, vomer, and the median crest formed by the apposition of the palatine plates of the maxillæ and the horizontal plates of the palate bones. The anterior border has a triangular outline, limited above by the mesethmoid, and below by the vomer. This receives the triangular cartilage of the nose. The posterior border is formed by the pharyngeal edge of the vomer. The septum is usually deflected to one side, and is occasionally perforated. Sometimes a strip of cartilage, continuous with the triangular cartilage, persists between the vomer and mesethmoid.

The **outer wall** is formed by the nasal process and inner wall of the maxilla, the lachrymal, the ethmoidal and inferior turbinals, the vertical plate of the palate bone, and the inner surface of the internal pterygoid plate. The outer wall presents three recesses or **meatuses.** The **superior meatus,** the shortest, is situated between the superior and middle turbinal; it opens posteriorly; two orifices are in relation with it, namely, the orifice of the **posterior ethmoidal cells** and the **spheno-palatine foramen.** The **middle meatus** lies between the middle and inferior turbinals. It opens anteriorly and posteriorly. This meatus has two orifices communicating with it—the **opening** of the **antrum** (which is of very irregular shape) and the termination of the **infundibulum.** The **inferior meatus** is situated between the inferior turbinal and the floor of the fossa; it presents near its anterior part, under cover of the turbinal, the terminal orifice of the **nasal duct.** This is the largest meatus, and, like the middle, opens anteriorly and posteriorly.

The **anterior narial orifices** are bounded above by the lower border of the nasal bones, laterally by the maxillæ, and inferiorly by the premaxillary portions of the maxillæ. In the recent state they are separated by the triangular cartilage; in the dried skull the most anterior inferior limit is the **anterior nasal spine.**

The **posterior narial orifices** are bounded above by the alæ of the vomer, the sphenoidal process of the palate bones, and the under surface of the sphenoid; externally by the internal pterygoid plates; and inferiorly by the posterior border of the horizontal plates of the palate bones. They are divided by the posterior border of the vomer and the posterior nasal spine.

FIG. 88.—SECTION THROUGH THE NASAL FOSSA TO SHOW THE OUTER WALL WITH THE MEATUSES.



The nasal fossæ communicate with all the more important fossæ and sinuses of the skull. By means of the foramina in the roof they are in connection with the cranial cavity. The infundibulum brings each fossa in communication with the frontal and anterior ethmoidal cells. The posterior ethmoidal and the sphenoidal cells open into the superior meatuses. The spheno-palatine foramina connect them with the spheno-maxillary fossæ, and an irregular orifice in each outer wall causes them to communicate with the antra. The nasal ducts connect them with the orbits, and the anterior palatine canals with the buccal cavity.

The **sutures** visible in an anterior view of the skull are numerous, and for the most part unimportant:—

The **transverse** suture extends from one external angular process to the other. The upper part of the suture is formed by the frontal bone; below are the malar, greater and lesser wings of the sphenoid, os planum, lachrymal, maxillary, and nasal bones. A portion of this complex suture, lying between the sphenoidal and frontal bones, appears in the anterior cranial fossa.

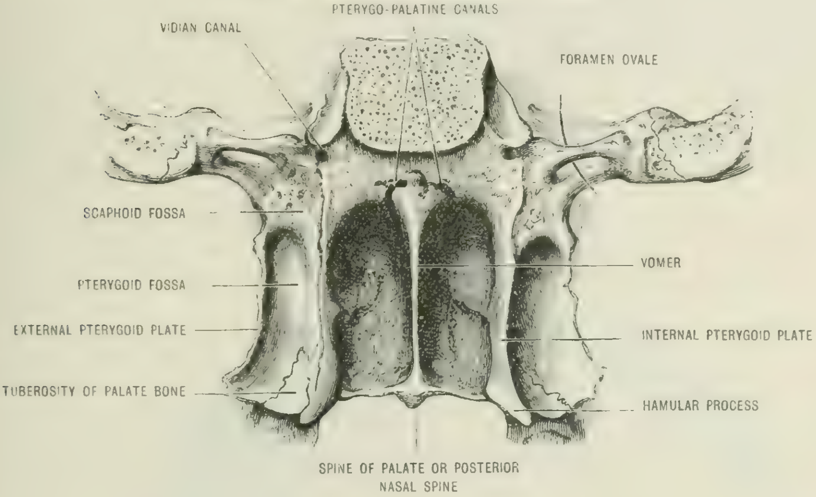
Other and less important fissures are the internasal, naso-maxillary, intermaxillary, and malo-maxillary. The small sutures visible in the orbit have been already mentioned in describing that cavity.

The following points are seen in an anterior view of the cranium:—

The **glabella**, a smooth space between the converging superciliary ridges.

The **ophryon** is the most anterior point of the metopic suture.

FIG. 89.—THE POSTERIOR NARES.



The **nasion** is the central point of the transverse suture.

The **subnasal point** is the middle of the inferior border of the anterior nasal aperture at the base of the nasal spine.

The **alveolar point** is the centre of the anterior margin of the upper alveolar arch.

THE INTERIOR OF THE SKULL

In order to study the interior of the skull it is necessary to make sections in three directions,—sagittal, coronal, and horizontal. This enables the student to examine the various points with facility, and displays the great proportion the brain cavity bears to the rest of the skull. The **sagittal section** should be made slightly to one side of the median line in order to preserve the nasal septum. The black line (fig. 90) drawn from the **basion** (anterior margin of the foramen magnum) to the **gonion** (the anterior extremity of the sphenoid) represents the **basi-cranial axis**; whilst the line drawn from the **gonion** to the **subnasal point** lies in the **basi-facial axis.** These two axes form an angle termed the **cranio-facial**, which is useful in making comparative measurements of crania. A line prolonged vertically upwards from the **basion** will strike the **bregma.** This is the **basi-bregmatic** axis, and gives the greatest height of the cranial cavity. A line drawn from the **ophryon** to the **occipital point** indicates the greatest length of the cranium.

Near its middle, the cranial cavity is encroached upon by the petrosal; the walls are channelled vertically by narrow grooves for the middle and small meningeal arteries, and towards the base and at the vertex broader furrows are found for the venous sinuses.

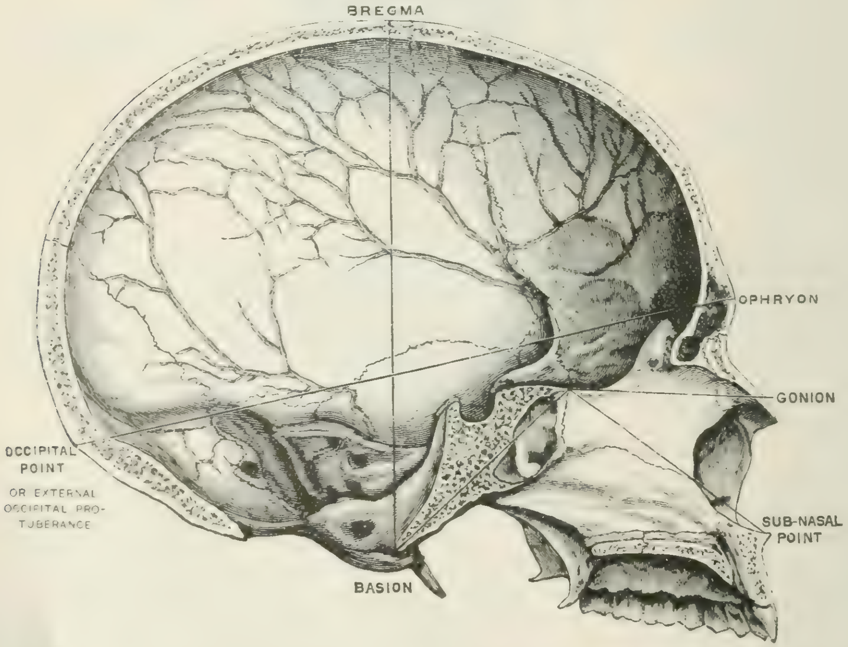
The **coronal** section is most instructive when made in the **basi-bregmatic** axis. The section will pass through the petrosal in such a way as to traverse the two external auditory passages and expose the tympanum and vestibule, and will also partially traverse the internal auditory meatuses. Such a section will divide the parietal bones slightly posterior to the parietal eminences, and a line drawn transversely across the section at the mid-point will give the greatest transverse measurement of the cranial cavity. A skull divided in this way facilitates the examination of the parts about the posterior nares.

The **horizontal section** of the skull should be made through a line extending from the **ophryon** to the **occipital point,** passing laterally a few millimetres above the **pterion** on each side. It is of great advantage to study the various parts on the floor of the cranial cavity in a second skull having the dura mater and its various processes *in situ.*

The **floor** of the cranial cavity presents three irregular depressions termed the anterior, middle, and posterior fossæ.

The Anterior Fossa.—The floor of this fossa is on a higher level than the rest of the cranial floor. It is formed by the horizontal plate of the frontal bone, the cribriform plate of the ethmoid, and the lesser wings of the sphenoid, which meet each other and exclude the pre-sphenoid from the anterior fossa. The free margins of the lesser wings and the optic groove mark the limits of this fossa posteriorly. The central portion of the fossa is depressed on each side of the crista galli, the depressions forming a part of the roofs of the nasal sinuses; laterally, the floor of this fossa is convex where it corresponds to the roof of the orbits, and is marked by irregular furrows. It supports the frontal lobes of the cerebrum. The **sutures** traversing the floor of the fossa are the fronto-ethmoidal, forming three sides of a rectangle, that portion of the transverse facial suture which traverses the roof of the orbit, and the ethmoido-sphenoidal suture, the centre of which corresponds to the **gonion.** The points of interest in the fossa are:—

Fig. 90.—The Skull in Sagittal Section.



A groove for the superior longitudinal sinus.

The **foramen cæcum** which transmits a small vein.

The **crista galli.**

The **ethmoidal fissure** for the nasal branch of the fifth nerve.

The cranial orifice of the **anterior ethmoidal canal,** transmitting the nasal branch of the fifth nerve, and a meningeal branch of the anterior ethmoidal artery.

Ethmoidal foramina for the olfactory filaments.

Cranial orifice of the **posterior ethmoidal canal,** transmitting a meningeal branch of the posterior ethmoidal artery.

The **ethmoidal spine** of the sphenoid.

Furrows for meningeal arteries.

The MIDDLE CRANIAL FOSSA presents a central isthmus and two lateral depressed portions. It is limited anteriorly by the posterior borders of the lesser wings of the sphenoid and the anterior margin of the optic groove. The posterior limits are the dorsum ephippii and the superior borders of the petrosals. Laterally it is bounded by the squamosals, the great wings of the sphenoid, and the parietal bones. The floor is formed by the body and greater wings of the sphenoid, and the anterior surfaces of the petrosals. It contains the following **sutures**: spheno-parietal, petro-sphenoid, squamo-sphenoidal, squamous, and a portion of the transverse suture. The central portion or isthmus of the middle fossa presents the following points from before backwards:—

The **optic groove,** which lodges the optic chiasma.

The **optic foramina,** transmitting the optic nerve and ophthalmic artery.

The **olivary process,** indicating the line of ankylosis between pre- and post-sphenoid.

The **anterior clinoid processes.**

The **pituitary fossa,** with the **middle clinoid processes,** and grooves for the internal carotid arteries. The **dorsum ephippii,** with the **posterior clinoid processes,** and notches for the sixth pair of cranial nerves.

This central depression is in direct relation with the parts of the brain surrounding the circle of Willis.

The *lateral depressions* receive the temporo-sphenoidal lobes of the brain, and are marked by numerous furrows roughly corresponding to the convolutions of the cerebrum. Numerous narrow diverging channels pass upwards from the fossa towards the vertex; these lodge the ramifications of the middle and small meningeal arteries.

The following openings occur on each side of this fossa:—

The **sphenoidal fissure,** leading into the orbit and transmitting the third, fourth, ophthalmic division of the fifth and the sixth nerves, and ophthalmic vein.

In the greater wing of the sphenoid near its union with the frontal bone there are small openings allowing twigs of the middle meningeal artery to enter the orbit.

The **foramen rotundum,** which conducts the second division of the fifth nerve into the spheno-maxillary fossa.

The **foramen ovale**: this transmits the third division of the fifth nerve with its motor root, the small meningeal artery, and the small superficial petrosal nerve.

The **foramen Vesalii** (not always present) for a small vein.

The **foramen spinosum,** for the middle meningeal artery and its venae comites.

The **middle lacerated foramen,** which transmits at its inner angle the internal carotid artery, with the carotid plexus of nerves.

On the posterior wall of this fossa the objects of interest are:—

A depression which lodges the Gasserian ganglion.

The **hiatus Fallopii,** for the great superficial petrosal nerve, and a twig from the middle meningeal artery.

A foramen for the small superficial petrosal nerve.

A minute foramen for the external superficial petrosal nerve.

An eminence formed by the superior semicircular canal.

Anterior and slightly external to the ridge formed by the superior semicircular canal, the bone is exceedingly thin and translucent. This is the roof of the tympanum (tegmen tympani). When the dura mater is *in situ*, the depression lodging the Gasserian ganglion is converted into a foramen, traversed by the fifth nerve. The notch in the side of the dorsum ephippii for the sixth nerve is also a foramen when the dura mater is present. In many skulls the middle clinoid process is prolonged to meet the anterior clinoid process, and thus forms a foramen for the internal carotid artery. The grooves for the middle meningeal arteries are sometimes canals or tunnels in a part of their course, especially in old skulls. The grooves radiate from the foramen spinosum and extend to the vault. The bones most deeply marked are the squamosal, the greater wing of the sphenoid, and the parietal.

Fig. 91.—The Skull in Horizontal Section.

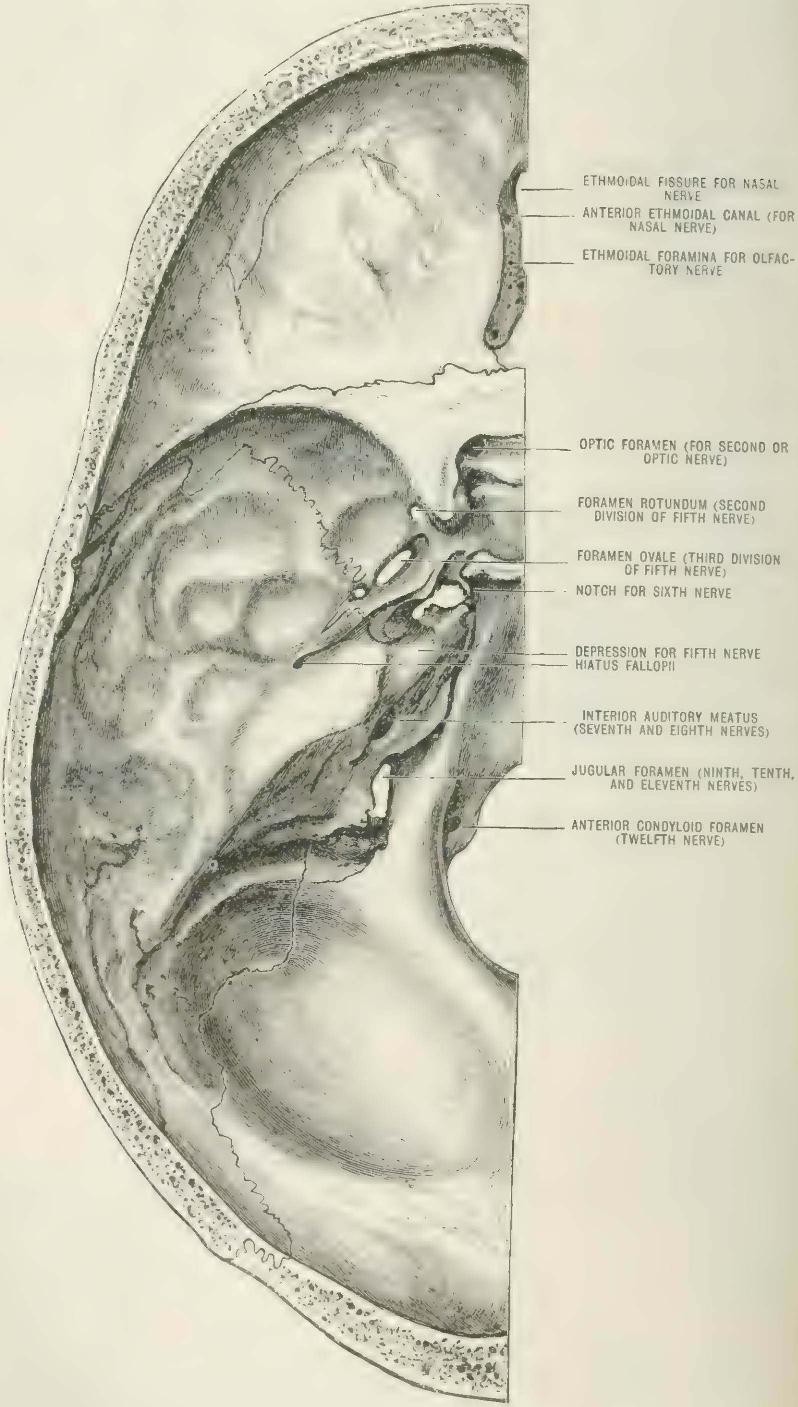
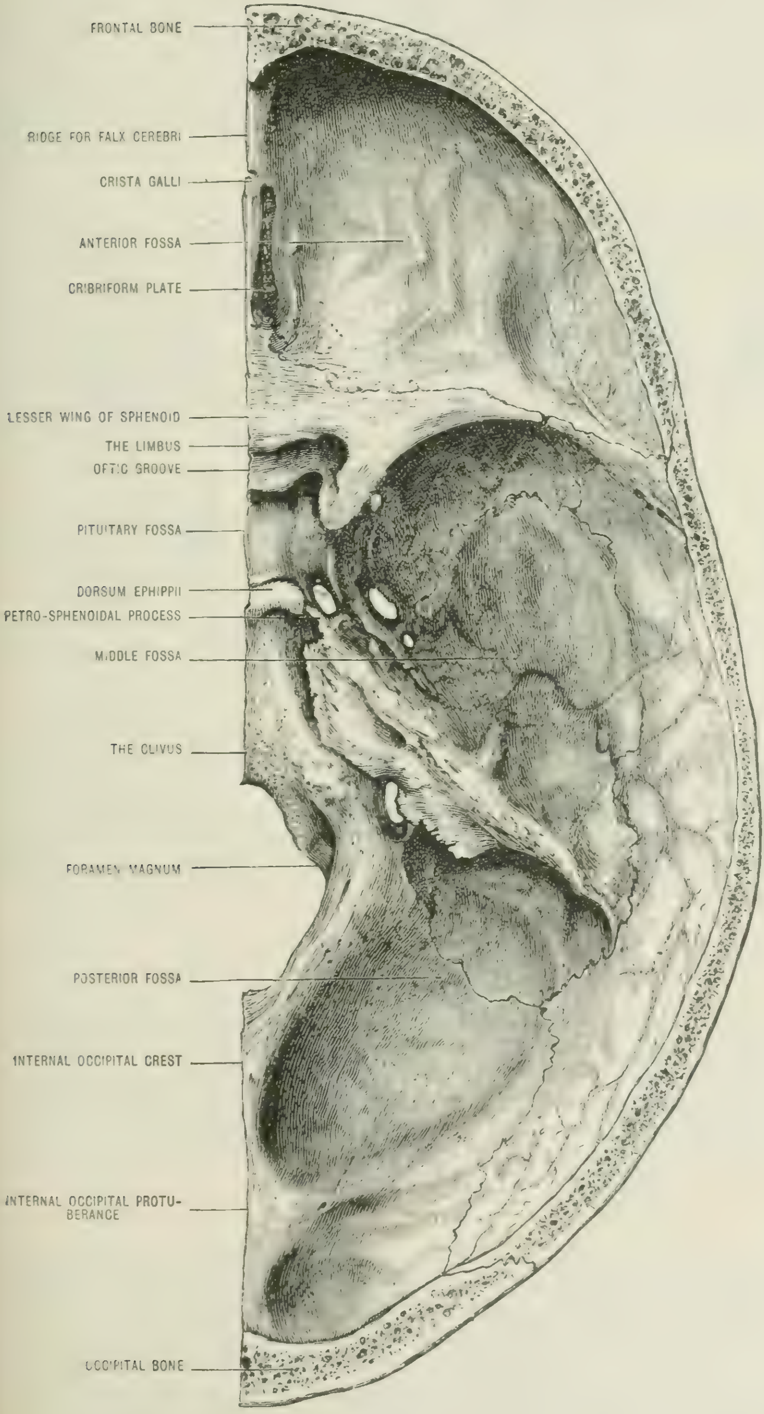

ETHMOIDAL FISSURE FOR NASAL NERVE
ANTERIOR ETHMOIDAL CANAL (FOR NASAL NERVE)
ETHMOIDAL FORAMINA FOR OLFACTORY NERVE
OPTIC FORAMEN (FOR SECOND OR OPTIC NERVE)
FORAMEN ROTUNDUM (SECOND DIVISION OF FIFTH NERVE)
FORAMEN OVALE (THIRD DIVISION OF FIFTH NERVE)
NOTCH FOR SIXTH NERVE
DEPRESSION FOR FIFTH NERVE
HIATUS FALLOPII
INTERIOR AUDITORY MEATUS (SEVENTH AND EIGHTH NERVES)
JUGULAR FORAMEN (NINTH, TENTH, AND ELEVENTH NERVES)
ANTERIOR CONDYLOID FORAMEN (TWELFTH NERVE)

FIG. 92.—THE SKULL IN HORIZONTAL SECTION.


FRONTAL BONE
RIDGE FOR FALX CEREBRI
CRISTA GALLI
ANTERIOR FOSSA
CRIBRIFORM PLATE
LESSER WING OF SPHENOID
THE LIMBUS
OPTIC GROOVE
PITUITARY FOSSA
DORSUM EPHIPPII
PETRO-SPHENOIDAL PROCESS
MIDDLE FOSSA
THE CLIVUS
FORAMEN MAGNUM
POSTERIOR FOSSA
INTERNAL OCCIPITAL CREST
INTERNAL OCCIPITAL PROTUBERANCE
OCCIPITAL BONE

The POSTERIOR CRANIAL FOSSA is the deepest portion of the cavity. It is bounded by the dorsum ephippii and the superior borders of the petrosals, the mastoid portion of the petrosals, the posterior inferior angle of the parietals, and the squamo-occipital below the level of the crest (supra-occipital). The upper limits are indicated by the grooves for the lateral sinuses. It is marked by the following **sutures**:—the petro-occipital, occipito-mastoid, parieto-mastoid, and, in young skulls, the basilar suture.

The ridges limiting this fossa give attachment to the tentorium cerebelli, and the fossa lodges the cerebellum with the pons and medulla. It communicates with the general cranial cavity by means of the foramen of Pacchionius when the tentorium is *in situ*.

It has the following objects of interest:—

The **clivus,** extending from the dorsum ephippii to the anterior margin of the foramen magnum. This is in relation with the basilar artery, the pons, the medulla, the sixth nerves and the basilar sinus.

The notch for the sixth nerve on each side of the dorsum ephippii. This is sometimes a foramen, termed the **petro-sphenoid.**

The **foramen magnum,** presenting on each side a tubercle for the check ligaments; and the **anterior condyloid foramen** (sometimes subdivided by a spiculum of bone) for the hypoglossal nerve. Behind the foramen there is a vertical ridge of bone, the internal occipital crest, for the falx cerebelli. This sometimes presents a depression known as the **vermiform fossa.**

The anterior boundaries of the fossa present:—

A notch for the passage of the fifth nerve. This is a foramen when the tentorium is present.

The **internal auditory meatus,** for the facial and auditory nerves, and the auditory branch of the basilar artery.

The **jugular foramen,** which transmits the glosso-pharyngeal, vagus, and spinal accessory nerves, the internal jugular vein, the meningeal branch of the ascending pharyngeal artery, aqueductus vestibuli and hiatus subarcuatus.

The termination of the groove for the lateral sinus, with the internal orifice of the **mastoid foramen.**

The cranium of an average European has a *capacity* of 1450 cc. The *circumference*, taken in a plane passing through the **ophryon** anteriorly, the **occipital point** posteriorly, and the **pterion** laterally, is 52 cm. The *length* from the **ophryon** to the **occipital point** is 17 cm.; the *width* between the parietals at the level of the zygomata is 12·5 cm.; and the *height* from the **basion** to the **bregma** is nearly the same. The cranio-facial angle is about 96°.

THE TEETH

An adult individual with perfect dentition possesses thirty-two teeth, equally distributed to the maxilla and mandible. The upper set are called maxillary teeth and the lower set mandibular. The four central teeth in each dental arch are termed incisors; the tooth next these on each side is the canine; behind these are two premolars or bicuspids; and lastly, three molars. This relation of teeth is expressed by means of a formula:—

$$i\,\frac{2}{2}\,c\,\frac{1}{1}\,prm\,\frac{2}{2}\,m\,\frac{3}{3}=32.$$

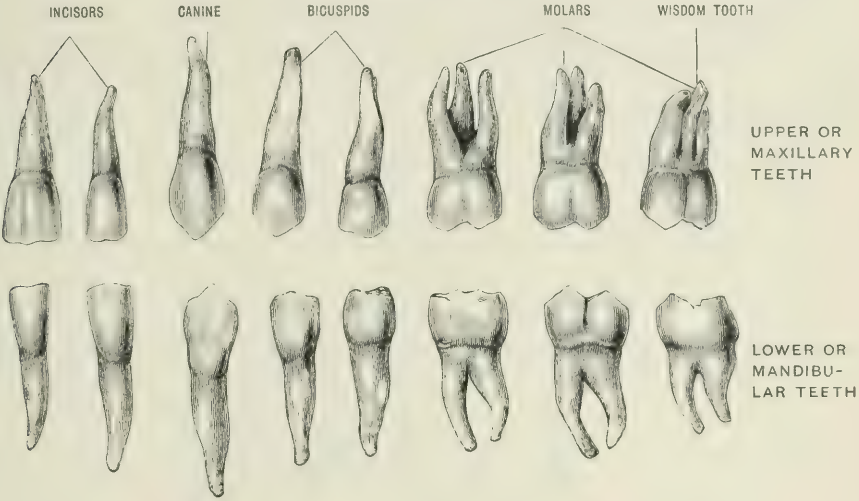
Each tooth has a portion coated with enamel exposed above the gum—named the **crown**; and a portion coated with cementum embedded in bone—this is the **root.** The line of union of the crown and root is termed the **neck.**

The surface of the tooth directed towards the lips and cheek is called **labial** and buccal respectively, and that towards the tongue **lingual.** It is also necessary to apply definite terms to the opposed surfaces of teeth, hence the surface directed towards the middle line of the mouth if the alveolar arch were straightened out is **median,** and the opposite side is **distal.** Each tooth has distinguishing features.

The incisors.—The central maxillary incisor is very much larger than the lateral, the crown is somewhat oblong in outline, its length exceeding the breadth. The median is longer than the distal border. The labial surface is convex, the lingual concave, and terminates near the gum in a low eminence, the basal ridge or **cingulum.** In recently erupted teeth, the cutting edge is elevated into three small cusps; these soon wear down and leave a straight edge. The root is long, single, and flattened laterally.

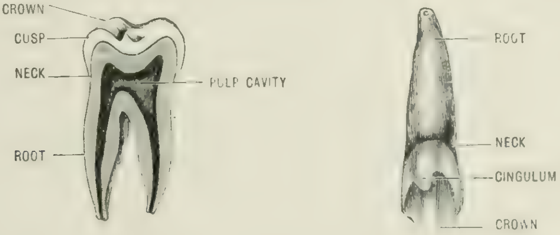
The maxillary lateral incisors are much smaller than the centrals, which they resemble in the general contour of the crown. The distal angle of the crown is more rounded than in the central incisors, and the cingulum is more pronounced. The root is single. The maxillary incisors are lodged in the premaxilla.

FIG. 93.—THE TEETH OF AN ADULT.



The mandibular central incisors are much narrower than those of the upper set, and less than half their width in the cutting edges, and the crown becomes contracted towards the neck. The cingulum is scarcely marked, and the root single. The lower lateral incisors are distinctly larger than the lower centrals in every direction. The distal angle of the crown is rounded off; the root is single and frequently presents on each side a longitudinal groove.

FIG. 94.—A MOLAR TOOTH IN SECTION, AND A CANINE TOOTH.



The canines.—These differ from the incisors in possessing larger crowns, and thick long roots. The crown ends in a blunt point, and the cutting edge slopes away on each side. The slope towards the bicuspid is the longer, and causes the crown to be asymmetrical. The lingual surface presents a median and two lateral ridges; they converge towards the well-marked cingulum, which is often produced into a distinct cusp.

The mandibular canines have not such pronounced features as the maxillary; the point is blunter, and the median ridge is absent from the lingual surface.

The maxillary premolars or bicuspids.—The crown of the first premolar has a grinding surface which is somewhat quadrilateral in outline; the labial is, however, longer than the lingual border. It has two cusps, of which the labial is much the larger. The cusps or tubercles are separated by a pit, but are connected by a narrow ridge along the median and distal borders. The median border is nearly straight, the distal is convex. The root may be single or it may be bifurcated near the apex or marked by a longitudinal depression, or be double throughout the greater part of its length; it may in some specimens have three distinct roots like a molar.

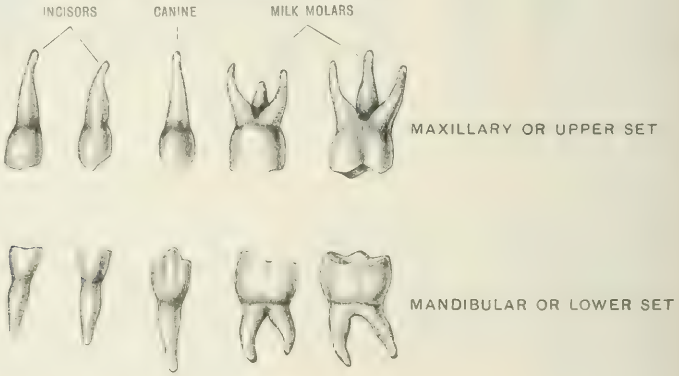
The second bicuspid differs from the first in having its cusps nearly equal in size. Its root is more deeply grooved.

The **mandibular bicuspids** are smaller than the upper and differ from them in shape. The labial cusp is larger than the lingual; the cusps are connected by a low ridge, the grinding surface presents two small pits. The root is single, rounded, and tapering.

The second lower bicuspid is larger than the first. The labial cusp is higher and stouter, and the distal border is much more pronounced. Its root is also single and tapering.

The maxillary molars.—The first and second resemble each other so closely that one description will serve for the two. The grinding surface is quadrilateral but with rounded angles. It has four cusps, two buccal and two lingual. Of these, the anterior lingual is the largest, and is connected with the posterior buccal by an oblique ridge of enamel. The groove separating the buccal and lingual cusps extends on to the sides of the crown and is lost near the neck. The median and distal borders usually present a slight ridge. The roots are three in number, two on the labial, and one on the palatine aspect; this last is usually referred to as the palatine root, and often diverges from the crown at a considerable angle.

Fig. 95.—The Temporary Teeth



The mandibular molars.—The first is the most constant in form. It has five cusps on the grinding surface. Four occupy the angles and are separated by a crucial fissure. The fifth cusp is situated at the posterior extremity of the longitudinal fissure. It has two roots, placed one in front of the other; they are inclined somewhat backwards, and present a vertical groove which is sometimes so deep as to divide each root, producing four roots. One root only may divide in this way.

The second molar differs from the first in the frequent absence of the fifth cusp; when present it is feebly developed. The roots have a tendency to become confluent.

The third molars (*wisdom teeth*).—The upper third molar resembles in its grinding surface the adjacent molars. The two palatine tubercles are usually blended, and the roots coalesce and taper to a cone. The apex is often bent. The characters of this tooth are very variable.

The third lower molar has a larger crown than the corresponding tooth in the upper set; it resembles the adjacent molars and has usually five cusps. It has two roots which may be confluent.

The Relations of the Crowns of the Upper and Lower Teeth to one another.—In a normal condition the upper teeth form a larger arch than the lower. The upper incisors and canines close in front of the lower; occasionally they fall upon, but rarely fall behind them. The labial tubercles of the bicuspids and molars of the lower jaw are received in the depressions between the labial and lingual tubercles of the upper set of teeth; hence the labial tubercles of the upper overlap the corresponding tubercles in the lower teeth.

In consequence of the difference in width of the crowns of the upper and lower incisors, it happens that in closure of the mouth each tooth impinges upon two teeth.

The milk teeth.—These are smaller in number and size than the teeth of the permanent set. The formula is:—

$$di\,\frac{2}{2}\;dc\,\frac{1}{1}\;dm\,\frac{2}{2} = 20.$$

The temporary teeth are smaller than their successors; the enamel of the crown terminates in a thick edge; and the tubercles on the crowns of the molars are less regular and pronounced.

The incisors are similar to those of the permanent set, but the canines have shorter and broader crowns than their successors.

THE MORPHOLOGY OF THE SKULL

In Man the skull during development passes through three stages. At first the brain vesicles are enclosed in a sac of indifferent tissue which ultimately becomes tough and fibrous. This is the **membranous cranium**; a portion of it is represented in the adult by the dura mater, the remainder is converted into the membrane-bones. Gradually the sides and base of the membranous cranium become cartilaginous: in due course osseous tissue appears in the membranous tracts, and later in the cartilage. Eventually an **osseous box** is formed, consisting of membrane-bones and cartilage bones intricately interwoven.

A study of the skull in the chondral stage is very instructive. It consists of two parts: (1) The skull proper; and (2) the appendicular elements.

The skull proper consists of three regions:—

The **basi-cranial** or **notochordal** region, which ultimately gives rise to the chief parts of the occipital bone and a part of the sphenoid.

Anterior to this is the **trabecular region**, from which the remainder of the sphenoid is subsequently developed.

The most anterior portion is the **ethmo-vomerine region**, from which the nasal septum and its associated cartilages arise. Wedged in on each side between the basi-cranial and trabecular regions is the complicated **periotic** capsule.

The **appendicular elements** of the cranium are a number of cartilaginous rods, which undergo a remarkable metamorphosis, and, in the adult, are represented by the **ear-bones**, the **styloid process**, and the **hyoid**.

The **chondro-cranium** at the third month presents the following parts. Seen from above, the cartilage extends from the cranial base to a spot midway between the base and the vertex, shading off indefinitely on the membranous wall. The conspicuous oval masses on each side are the **periotic cartilages**, in which the floccular fossæ are conspicuous objects. Each periotic cartilage is joined to the sphenoid by a strip, termed the **sphenotic cartilage**, which usually persists in the adult skull. At this date the cartilage for the orbito-sphenoid (the so-called lesser wing) is co-extensive with the ali-sphenoid, and forms part of the lateral wall of the skull. The snout-like appearance of the anterior part of the skull is caused by the **fronto-nasal** plate. On each side of the ethmo-vomerine plate near its anterior termination there are two small concave pieces of cartilage for Jacobson's organ. They are sometimes referred to as the plough-share cartilages owing to their shape.

The Metamorphosis of the Branchial Bars

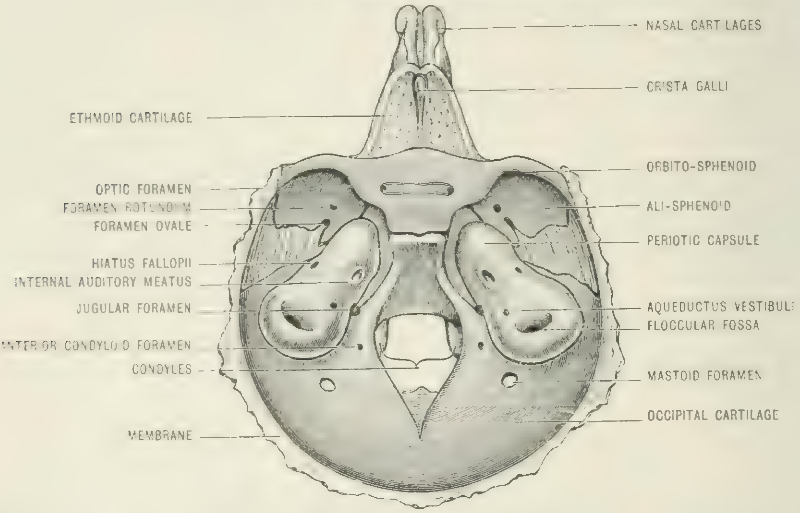
These rods of cartilage are named, from before backwards, the **mandibular, hyoid,** and **thyroid** bars. They may with care be easily dissected in the fœtus between the third and fourth months. Their metamorphosis is as follows:—

The two extremities of the **mandibular bar** ossify; the distal end ultimately forms that portion of the mandible adjacent to the symphysis; the proximal end ossifies as the **malleus.** The intermediate portion disappears; the only vestige is a band of fibrous tissue, the spheno-mandibular ligament, extending from the spine of the sphenoid to the spine of the mandible.

The **hyoid bar** fuses distally with the thyroid bar, and is represented by the **hyoid bone.** Its proximal end becomes the **incus, tympano-hyal,** and **styloid process**; the intervening strip is represented in the adult by the stylo-hyoid ligament.

The **styloid process** has two centres of ossification. A nucleus appears anterior to the stylo-mastoid foramen, and is known as the **tympano-hyal.** At birth the true **styloid process** is cartilaginous. In the second year it ossifies, and subsequently becomes firmly ankylosed to the tympano-hyal. Occasionally the hyoid bar may ossify throughout. When this is the case the styloid process reaches to the hyoid and replaces the stylo-hyoid ligament.

FIG. 96.—THE CHONDRO-CRANIUM.



The **stapes** originates in a piece of cartilage which is traversed by the temporary stapedial artery. Its centres of ossification require investigation. The **internal pterygoid** plate arises in a piece of cartilage which represents the **palato-quadrate** of lower vertebrates. The internal pterygoid plate is an appendicular element engrafted on to the sphenoid. In many mammals it is a separate bone throughout life. In the same way the styloid process is an appendicular element ankylosed to the petrosal and the tympanic plate; in many mammals it remains separate throughout life.

The Skull at Birth

The skull at birth presents, when compared with the adult skull, several important and interesting features. Its peculiarities may be considered under three headings:—The peculiarities of the fœtal skull as a whole; the condition of individual bones; the remnants of the chondral skull.

The general characters of the fœtal skull.—The most striking features of the skull at birth are, its relatively large size in comparison with the body, and the predominance of the cerebral over the facial portion of the skull; the latter is, in fact, very small.

The frontal and parietal eminences are large and conspicuous; the sutures are absent; the adjacent margins of the bones of the vault are separated by septa of fibrous tissue continuous with the dura mater internally and the pericranium externally; hence it is difficult to separate the roof bones from the underlying dura mater, each bone being lodged as it were in a dense membranous sac. The bones of the vault consist of a single layer without any diploë, and their cranial surfaces present no digital impressions. Six membranous spaces exist, named fontanelles: two are median, named anterior and posterior; and two exist on each side, termed anterior and posterior lateral fontanelles. Each angle of the parietal bones is in relation with a fontanelle.

The anterior fontanelle is lozenge-shaped, the posterior triangular. The lateral fontanelles are irregular in outline.

Turning to the base of the skull, the most striking points are the absence of the mastoid processes and the large angle which the pterygoid plates form with the skull-base, whereas in the adult the angle is almost a right one. The base of the skull is relatively short, and the lower border of the mental symphysis is on a level with the occipital condyles.

FIG. 97.—THE CRANIUM AT BIRTH.

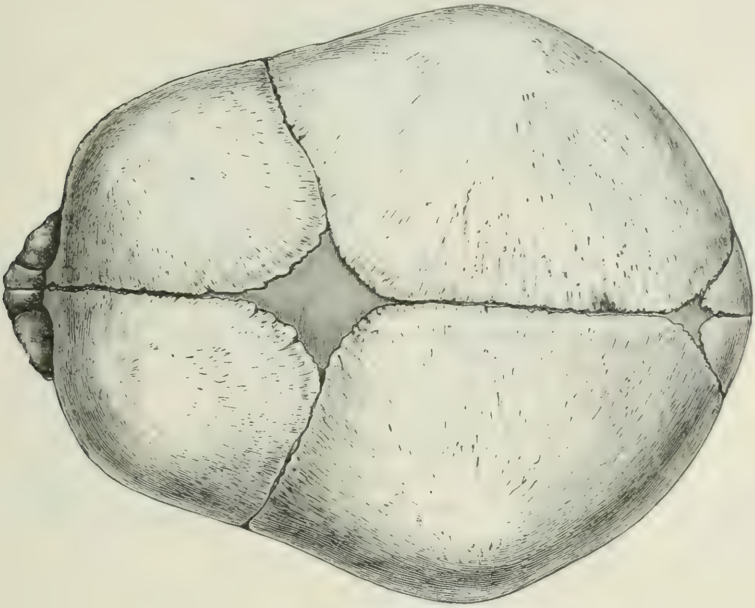
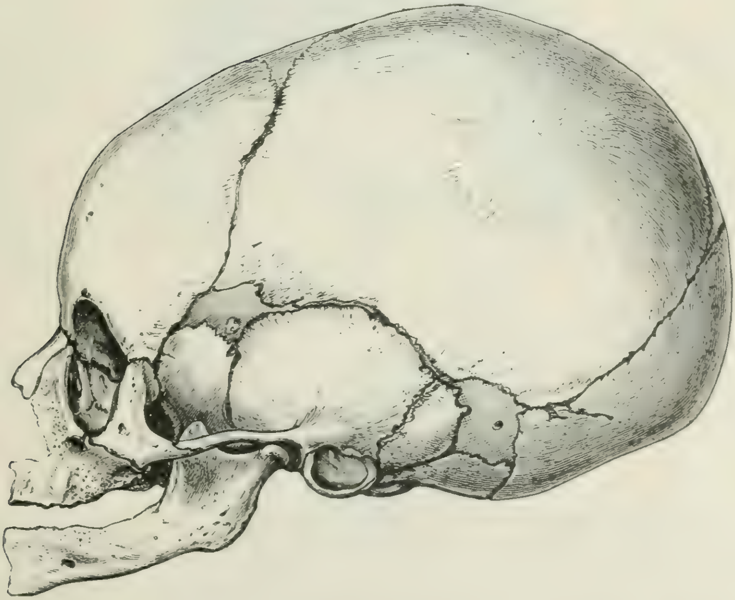


FIG. 98.—THE CRANIUM AT BIRTH.



The facial skeleton is relatively small in consequence of the small size of the nasal fossæ, the small size of the antrum, and the rudimentary condition of the alveolar borders of the maxillæ and mandible; these are as wide as they are high, and are almost filled with the turbinals.

Fig. 99.—The Cranium at Birth in Sagittal Section.

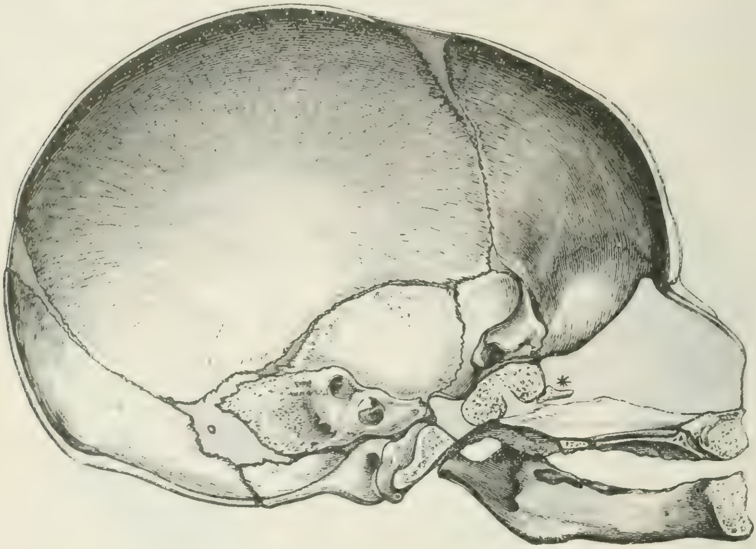
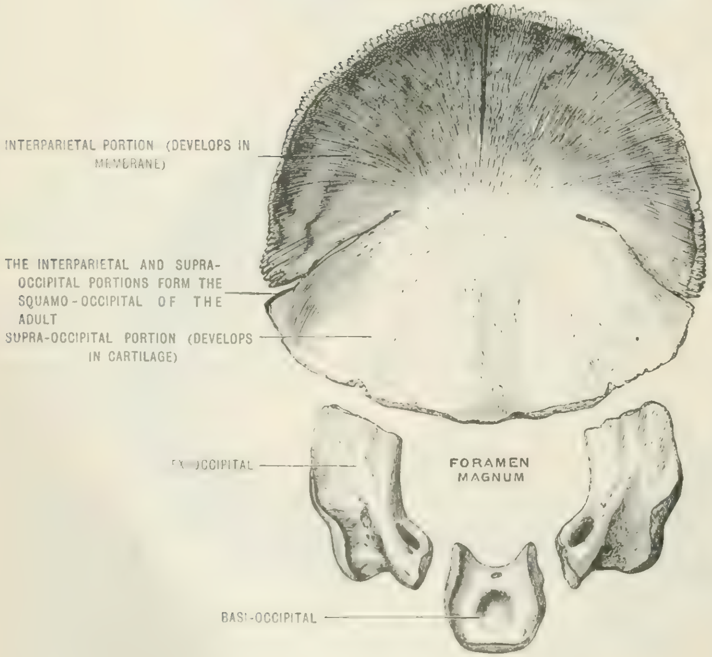


Fig. 100.—The Occipital at Birth.


INTERPARIETAL PORTION (DEVELOPS IN MEMBRANE)
THE INTERPARIETAL AND SUPRA-OCCIPITAL PORTIONS FORM THE SQUAMO-OCCIPITAL OF THE ADULT
SUPRA-OCCIPITAL PORTION (DEVELOPS IN CARTILAGE)
EX-OCCIPITAL
FORAMEN MAGNUM
BASI-OCCIPITAL

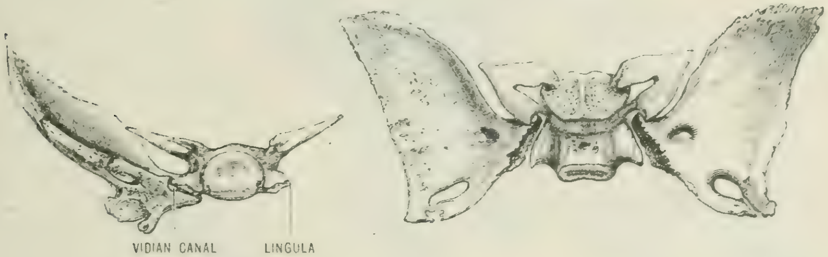
The Peculiarities of Individual Bones at Birth

The **occipital** consists of four distinct parts: the **basi-occipital**, two **ex-occipitals**, and the **squamo-occipital**; these four parts are united by hyaline cartilage. Compared with the adult bone, the following are the most important points of distinction:—There is no **pharyngeal**

tubercle or **jugular process**; the squamo-occipital presents two deep fissures separating the interparietal from the supraoccipital portion, and extending nearly as far inwards as the occipital protuberance. The grooves for the lateral sinus are absent.

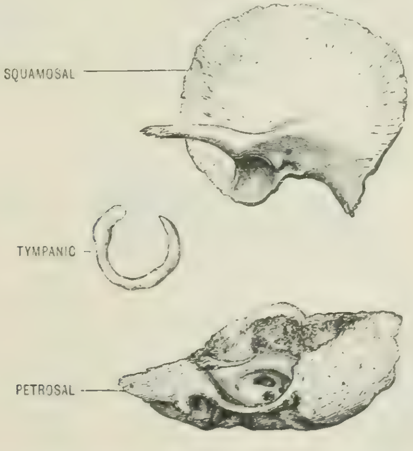
The **sphenoid** in a macerated fœtal skull falls into three pieces. The main portion consists of the united **pre-** and **post-sphenoid** with the **orbito-sphenoids** and **lingulæ**. The **pre-sphenoid** is quite solid and connected with the ethmo-vomerine cartilage, and presents no traces of the air sinuses which occupy this part in the adult skull. The pre-sphenoid by its upper surface forms part of the anterior cranial fossa, from which it is subsequently excluded by the orbito-sphenoids. The optic foramina are large and triangular in shape. The **lingulæ** stand out from the basi-sphenoid as two lateral buttresses, and the floor of the sella turcica presents the **cranio-pharyngeal canal**, which in a recent bone is occupied by fibrous tissue. The **dorsum ephippii** is yet cartilaginous. The **ali-sphenoids** with the pterygoid processes are separated from the rest of the bone by cartilage. The foramen rotundum is complete, but the future foramen ovale is merely a deep notch in its posterior border, and there is no foramen spinosum. The pterygoid processes are short, and each internal pterygoid plate presents a broad surface for articulation with the lingulæ. The **Vidian canal** is a groove between the internal pterygoid plate, the lingula, and greater wing.

FIG. 101.—THE SPHENOID AT BIRTH.



The **temporal bone** at birth consists of three parts (excluding the ear-bones): the **petrosal**, **squamosal**, and **tympanic**. The **petrosal** presents a large and conspicuous floccular fossa; the hiatus Fallopii is a shallow bay lodging the geniculate ganglion of the facial nerve. There is a relatively large mastoid antrum, but no mastoid process. The styloid process is unossified, but the **tympano-hyal** may be detected as a minute rounded nodule of bone near the stylo-mastoid foramen.

FIG. 102.—THE TEMPORAL BONE AT BIRTH.



The **squamosal** has a very shallow glenoid fossa and a relatively large post-glenoid tubercle. The posterior part of the inferior border is prolonged downwards into an uncinate process to close externally the mastoid antrum.

The **tympanic** bone or annulus is a delicate horseshoe-shaped ossicle, attached by its anterior and posterior horns to the inferior border of the squamosal.

The **ear-bones** are chiefly of interest from their size, for they are as large at birth as in the adult. The processus gracilis (Folian process) may be 2 cm. in length.

The **frontal** consists of two bones separated by a median vertical (metopic) suture. The frontal eminence is very conspicuous, but the superciliary ridges and frontal sinuses are wanting. The nasal spine, which later becomes one of the most conspicuous features of this bone, is absent. There is no temporal ridge.

Fig. 103.—The Temporal Bone at Birth. (Outer view.)

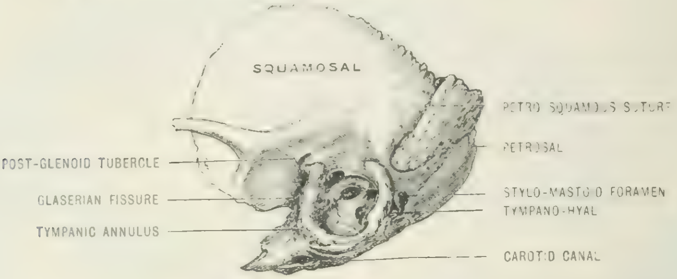
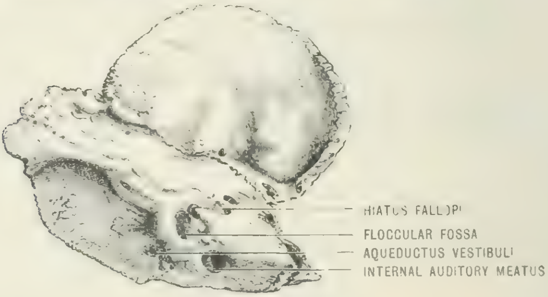
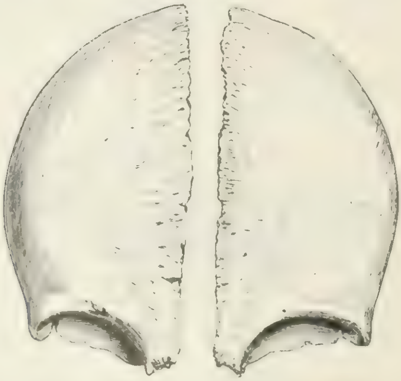

SQUAMOSAL
PETRO SQUAMOUS SUTURE
PETROSAL
POST-GLENOID TUBERCLE
GLASERIAN FISSURE
STYLO-MASTOID FORAMEN
TYMPANO-HYAL
TYMPANIC ANNULUS
CAROTID CANAL

Fig. 104.—Temporal Bone at Birth. (Inner view.)


HIATUS FALLOPII
FLOCCULAR FOSSA
AQUEDUCTUS VESTIBULI
INTERNAL AUDITORY MEATUS

The **parietal** is simply a quadrilateral lamina of bone, concave on its inner and convex on the outer surface. The parietal eminence, which indicates the spot in which the ossification of the bone commenced, is large and conspicuous. The grooves for blood-sinuses, as in other cranial bones, are absent. Each angle of the parietal is in relation with a fontanelle. As in the adult, the anterior inferior angle of the bone is prolonged downwards towards the ali-sphenoid.

Fig. 105.—The Frontal at Birth.



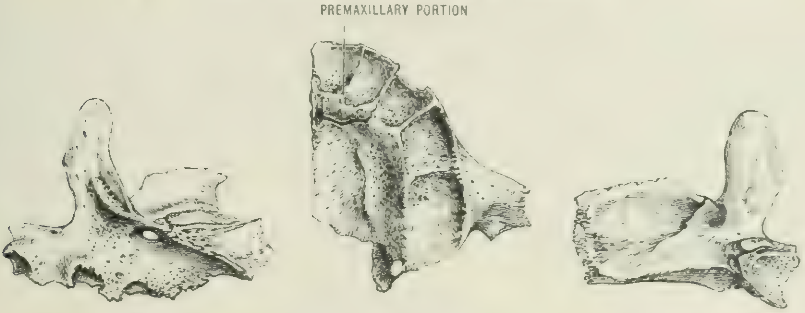
The **ethmoid** consists of two lateral portions separated by the still cartilaginous ethmo-vomerine plate. The ethmoid cells are represented by shallow depressions, and the uncinate process is undeveloped.

The **sphenoidal turbinals** are two small triangular pieces of bone lying in the perichondrium on each side of the ethmo-vomerine plate near its junction with the pre-sphenoid. (Indicated by the * in fig. 99.)

The **maxilla** presents the following characters:—The maxillo-premaxillary suture is visible on the palatine aspect of the bone. The alveolar border presents five sockets for teeth. The infraorbital foramen communicates with the floor of the orbit by a deep fissure; this fissure sometimes persists in the adult. The antrum is a shallow groove.

The **mandible** at birth consists of two halves united by fibrous tissue in the line of the future symphysis. Each half is a bony trough lodging teeth. The trough is divided by thin osseous partitions into five compartments: of these, the fifth is the largest, and is often subdivided by a ridge of bone. The floor is traversed by a furrow as far forward as the fourth socket (that for the first milk molar), where it turns outwards at the mental foramen. This furrow lodges the mandibular (inferior dental) nerve and artery, which enter by the large mandibular foramen. The condyle is on a level with the mental extremity of the bone.

Fig. 106.—The Maxilla at Birth.



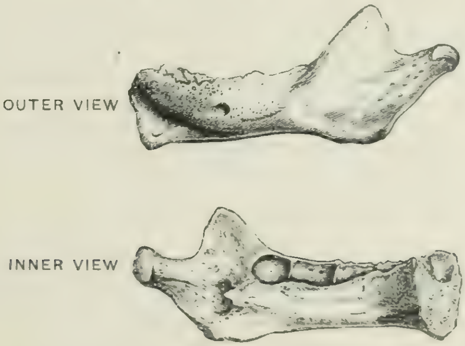
Outer view. Inferior view. Inner view.

The **palate bones** differ mainly from the adult bone in that the vertical and horizontal plates are of the same length; thus the nasal fossæ in the fœtus are as wide as they are high, whereas in the adult the height of each nasal fossa greatly exceeds the width.

Concerning the remaining bones little need be said. The **vomer** is a delicate trough of bone for the reception of the inferior border of the ethmo-vomerine plate; its inferior border, that which rests upon the palate, is broad, and the bone presents quite a different appearance from the adult vomer. The **nasal bones** are short but broad; the **malar** and **inferior turbinals** are relatively very large; and the **lachrymals** are thin, frail, and delicate lamellæ.

The **hyoid** consists of its usual five parts. There is a median nucleus for the basi-hyal, and one on each side for the greater cornua (thyro-hyals). The lesser cornua are cartilaginous.

Fig. 107.—The Mandible at Birth.



Remnants of the cartilaginous cranium.—It has already been pointed out that at an early date the base of the skull and the face are represented by hyaline cartilage, which for the most part is replaced by bone before birth. Even at birth remnants of this primitive chondral skull are abundant. In the cranium, cartilaginous tracts exist between the various portions of the occipital bone, as well as at the line of junction of the occipital with the petrosal and sphenoid. The dorsum ephippii is entirely cartilaginous at birth, and the last portion of this cartilage disappears with the ankylosis of the basi-occipital and basi-sphenoid about the twenty-fifth year. A similar strip of cartilage lying between the jugular process and the jugular surface of the petrosal persists until late in life. A strip of cartilage unites the ali-sphenoids with the lingulæ, and for at least a year after birth this cartilage is continuous with that which throughout life occupies the sphenotic (middle lacerated) foramen. A strip of cartilage exists along the posterior border of the orbito-sphenoid, and not unfrequently extends outwards to the pterion. In the adult skull it is replaced by ligamentous tissue.

The ethmo-vomerine plate is entirely cartilaginous, and near the end of the nose supports the lateral nasal cartilages, remnants of the fronto-nasal plate. The fate of the ethmo-vomerine plate is instructive. The upper part is ossified to form the mesethmoid; the lower part atrophies from the pressure exerted by the vomer; the tip remains as the triangular cartilage. The lateral snout-like extremities of the fronto-nasal plate persist as the lateral cartilages of the nose.

Among the appendicular elements of the skull, the styloid process and a large portion of the hyoid are cartilaginous at birth.

The Nerve-foramina of the Skull

The various foramina and canals in the skull which give passage to nerves may be arranged in two groups, **primary** and **secondary**. **Primary** foramina indicate the spots where the nerves quit the general cavity of the dura mater, and as this membrane indicates the limit of the primitive cranium, a cranial nerve, in a morphological sense, becomes extra-cranial at the point where it pierces this membrane. In consequence of the complicated and extraordinary modifications the vertebrate skull has undergone, many nerves traverse, in the adult skull, bony tunnels and canals which are not represented in the less complex skulls of low vertebrates such as sharks and rays. To such foramina and canals the terms **secondary** or **adventitious** may be applied.

Nerve-foramina are further interesting in that they occupy sutures, or indicate the points of union of two or more ossific centres. To this rule the foramen rotundum is the only exception in the human skull.

The Primary Foramina

1. **Foramen magnum.**—This is bounded by four distinct centres, the supra-, basi-, and two ex-occipitals. It transmits the spinal accessory nerve, the vertebral artery and its anterior and posterior spinal branches, the spinal cord and its membranes.

2. **The anterior condyloid.**—At birth this is a deep notch in the anterior extremity of the ex-occipital, and becomes a complete foramen when the basi- and ex-occipitals fuse. Occasionally it may be complete in the ex-occipital, but it indicates accurately the line of union of these two elements of the occipital bone. It transmits the hypoglossal nerve, the meningeal branch of the ascending pharyngeal artery, and its venæ comites.

3. **Jugular foramen.**—This occupies the petro-occipital suture, and is formed by the basi- and ex-occipital in conjunction with the petrosal. It transmits the glosso pharyngeal, pneumogastric, and spinal accessory nerves, a meningeal branch of the ascending pharyngeal artery, and receives the lateral and inferior petrosal sinuses.

4. **Auditory.**—This marks the point of confluence of the groups of centres termed pro-otic and opisthotic. It transmits the facial and auditory nerves with the auditory twig of the basilar artery.

5. **Trigeminal.**—This is only a foramen when the dura mater is present in the skull. It is a notch at the apex of the petrosal converted into a foramen by the tentorium. The main trunk of the trigeminal nerve with the small motor root traverses it to enter the Meckelian cave.

6. **Petro-sphenoidal.**—This is a notch between the side of the dorsum ephippii and apex of the petrosal which becomes converted into a foramen by dura mater.

7. **Optic.**—This foramen is formed by the confluence of the orbito- and pre-sphenoidal centres. It opens into the orbit and transmits the optic nerve and ophthalmic artery.

The Secondary Nerve-foramina

Foramina transmitting the various subdivisions of the fifth nerve.—The primary foramen of exit for the trigeminal nerve is formed partly of bone and partly of membrane at the apex of the petrosal. The three divisions of the nerve issue through secondary foramina.

(*a*) The **sphenoidal fissure** is an elongated chink, bounded above by the orbital wing and below by the greater wing of the sphenoid, internally by the body of the sphenoid, and externally by the frontal. It opens into the orbit, and transmits the third, fourth, first (ophthalmic) division of the fifth, and sixth nerves, also the ophthalmic vein.

(*b*) The **foramen rotundum** is the only exception to the rule relating to the formation of nerve-foramina; it is probably a segment of the sphenoidal fissure. The foramen is really a canal running from the middle cranial fossa to the spheno-maxillary fossa, and transmits the second or maxillary division of the trigeminal.

(*c*) The **foramen ovale** at birth is a gap in the hinder border of the greater wing (ali-sphenoid) of the sphenoid, and is converted into a foramen by the petrosal; subsequently it becomes complete in the sphenoid. It transmits the third or mandibular division of the trigeminal and the small or motor root, the small superficial petrosal nerve (which occasionally passes through a separate foramen), and the small meningeal artery with its venæ comites.

The ethmoidal canals.—These commence in the suture between the os planum and the frontal bone, and traverse the space between the upper surface of the lateral mass of the ethmoid and the horizontal plate of the frontal, to emerge on the cribriform plate; they are situated outside the dura mater. The anterior foramen transmits the nasal branch of the ophthalmic, which subsequently gains the nasal cavity by passing through the nasal slit (ethmoidal fissure) by the side of the crista galli.

The **infraorbital canal** indicates the line of confluence of the maxillary and malar centres of the superior maxilla; occasionally it is completed by the malar: rarely it is incomplete above, and communicates by a narrow fissure with the orbit. It lodges the infraorbital nerve and artery.

The **spheno-malar foramen** is situated in the suture between the malar and the greater wing of the sphenoid (ali-sphenoid); it transmits the temporal branch of the orbital nerve and a branch of the lachrymal artery. In the adult this foramen may be wholly confined to the malar bone.

The **malar canals** traverse the malar bone, and indicate the line of confluence of the two chief centres for this bone. The malar twigs of the orbital nerve issue from them accompanied by arterial twigs.

The **spheno-palatine foramen** is a deep groove between the orbital and sphenoidal processes of the palate bone, converted into a foramen by the sphenoidal turbinal. It is traversed by the naso-palatine nerve and artery as they enter the nasal from the spheno-maxillary fossa.

Scarpa's foramina are two minute openings in the meso-palatine suture where it is in relation with the anterior palatine fossa. They are traversed by the naso-palatine nerves.

The **pterygo-palatine foramen** is situated between the sphenoidal process of the palate bone, the internal pterygoid plate of the sphenoid, and the sphenoidal turbinal. The pterygo-palatine nerve and artery pass through it.

The **Vidian canal** is trumpet-shaped: the narrower end is situated in the sphenotic foramen; the broader orifice opens on the posterior wall of the spheno-maxillary fossa. The canal is 10 mm. long; in the fœtal skull it is a chink between the base of the internal pterygoid plate, the ali-sphenoid, and the lingula of the sphenoid. The canal is traversed by the Vidian branch of the spheno-palatine ganglion and the Vidian artery.

The **posterior palatine canal** is a passage left between the maxilla, the vertical plate and tuberosity of the palate bone, and the internal pterygoid plate; it commences on the hard palate by the posterior palatine foramen. The descending palatine nerve and artery traverse this canal. Several foramina open from it. In the suture between the vertical plate of the palate bone and the maxilla, two small openings allow minute nerves to issue for the middle and inferior turbinals. In the fissures between the tuberosities of the palate and maxillæ, and the pterygoid plates, the middle and external palatine nerves issue. These foramina are sometimes called accessory and external palatine canals.

The **mandibular** or **inferior dental canal** runs between the dentary and splenial elements of the mandible. The posterior orifice of the canal is the mandibular (inferior dental) foramen; the anterior orifice, the mental foramen, indicates the line of union of the mento-Meckelian and dentary centres. The mandibular nerve and artery enter the canal at its posterior orifice; the mental foramen allows the mental nerve to escape from the canal accompanied by the mental artery.

Foramina transmitting the facial nerve and its branches.—The main trunk of the facial enters the internal auditory meatus and traverses the Fallopian canal. In the early embryo the nerve lies on the petrosal, and is not covered in with bone until the fifth month of fœtal life. The terminal orifice, the **stylo-mastoid foramen**, is situated between the tympanic, tympano-hyal, and epiotic elements of the complex temporal bone.

The '**iter chordæ posterius**' is a chink between the squamosal and the tympanic elements, and allows the chorda tympani nerve to enter the tympanum. The fissure of exit for this nerve is the subdivision of the Glaserian fissure termed the canal of Huguier, or '**iter chordæ anterius.**' The **Glaserian fissure** lies between the tympanic plate and the squamosal. It transmits the tympanic branch of the internal maxillary artery, and lodges the slender process of the malleus.

The **spheno-maxillary fissure** is situated between the posterior border of the orbital plate of the maxilla and a smooth ridge on the orbital surface of the greater wing of the sphenoid. It transmits the superior maxillary division (second) of the fifth nerve.

THE RIBS AND STERNUM

The ribs.—These form a series of narrow flattened bones, twenty-four in number, arranged in twelve pairs, extending from the sides of the thoracic vertebræ towards the median line on the anterior aspect of the trunk.

The first seven pairs are termed **true ribs,** because their anterior ends are directly connected by means of cartilage with the sides of the sternum. The lower five—**false ribs**—are classed into two sets: the eighth, ninth, and tenth are connected together by their costal cartilages; the eleventh and twelfth have their anterior extremities free, and are called in consequence **floating ribs.** Thus the first seven are, **vertebro-sternal**; the eighth, ninth, and tenth, **vertebro-chondral**; the eleventh and twelfth, **vertebral ribs.**

The ribs increase in length from the first to the seventh, and then decrease from this rib to the twelfth.

In breadth they increase from behind forwards; the greatest breadth of a rib is at its junction with the costal cartilage. The two or three upper ribs form nearly a right angle with the spine, but the succeeding set curve obliquely downwards. The obliquity is greatest at the ninth, and then decreases in the ribs below.

Typical characters of a rib.—The seventh is regarded as the most typical rib. It presents a vertebral extremity or **head**; a narrow portion or **neck**; a **sternal** end; and an intermediate portion, the **shaft.**

The **head** has two facets divided by a horizontal crest. The crest is connected by an interosseous ligament with an intervertebral disc; the facets articulate with the demi-facets on the sides of the bodies of two vertebræ. As a rule, the lower facet is the larger, and articulates with the thoracic vertebra, to which the rib corresponds in number. This is the primary facet, and is the one represented in those ribs which possess only a single facet on the rib-head. The anterior margin is lipped for the costo-vertebral (stellate) ligament.

The **neck** is that portion of the rib extending from the head to the **tubercle.** The posterior surface of the neck is in relation with the transverse process of the lower vertebra with which the head articulates; it forms the anterior boundary of the **costo-transverse foramen,** and is rough where it gives attachment to the middle costo-vertebral ligament. The superior border of the neck is continuous with the corresponding border of the shaft, and at the point where the neck ends this border is produced so as to form a crest (*crista colli superior*) for the anterior costo-transverse ligament. The inferior border of the neck is continuous with the ridge of the **subcostal groove.** This difference in the relation of the neck to the upper and lower borders of the rib shaft is useful in determining to which side a rib belongs.

The **tubercle** consists of an upper part, rough for the posterior costo-transverse (rhomboid) ligament, and a lower faceted portion for articulation with the tip of the transverse process. The tubercle projects below the lower edge of the rib to form a crest (*crista colli inferior*), marking the beginning of the subcostal groove.

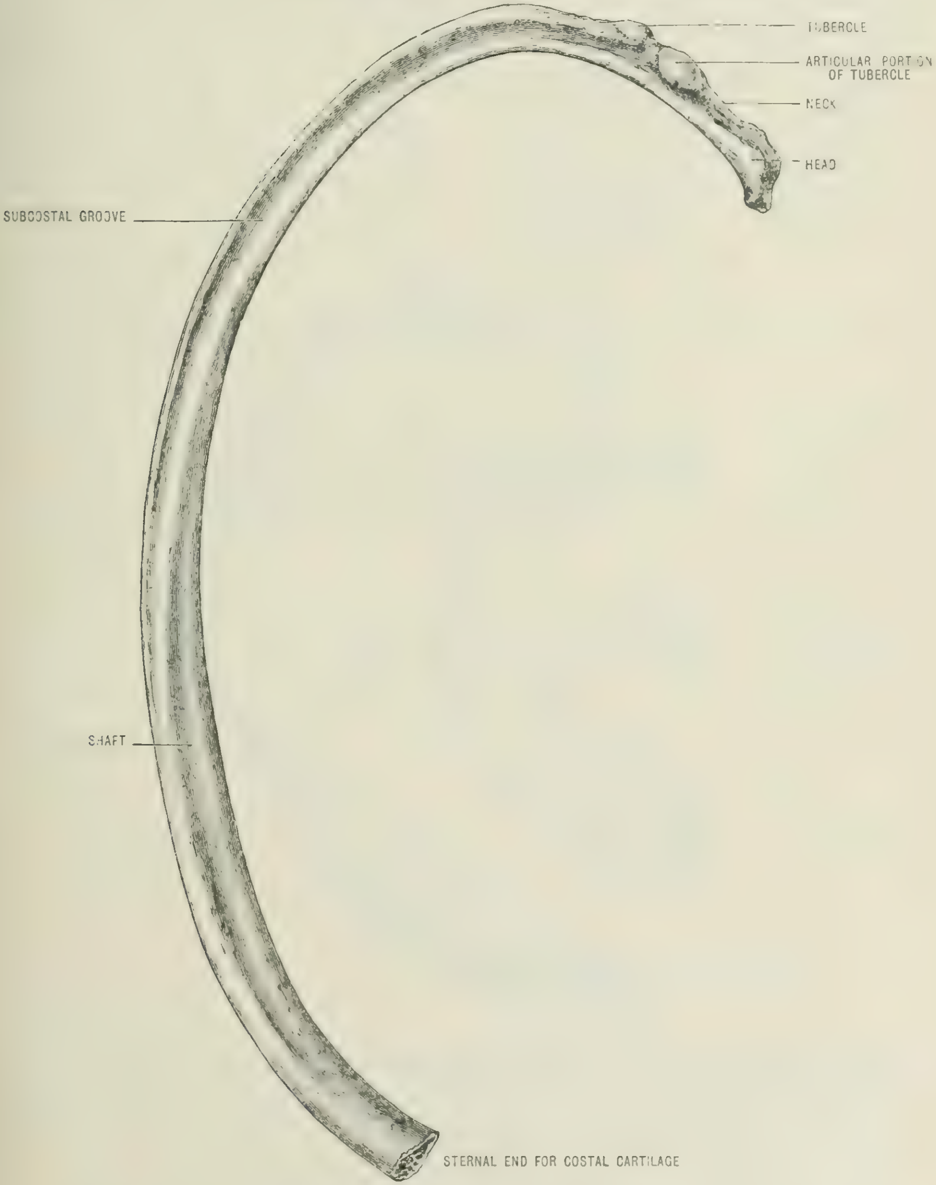
The **shaft** has two surfaces and two borders. It is strongly curved. At first the curve is in the same plane as the neck, but it quickly turns forwards at a spot on the posterior surface of the shaft known as the **angle,** where it gives attachment to the *sacro-lumbalis* muscle and some of its subdivisions. The rib has also a second or upward curve beginning at the angle. These curves are expressed by describing the main curve as disposed around a vertical, and the second or upward curve around a transverse axis.

When a rib, except the first and twelfth, is laid with its lower edge upon the table, the rib-head rises and the rib touches the table at two places, viz. at the sternal end, and in the neighbourhood of the angle.

The external surface of the rib is convex, and gives attachment to muscles. Near its anterior extremity it forms a somewhat abrupt curve, indicated by a ridge on the bone, which gives attachment to the *serratus magnus* muscle, and is sometimes called the **anterior angle.**

The internal surface is concave and presents the **subcostal groove** near its inferior border. The groove is best marked near the angle, and lodges the intercostal vessels and nerves. The ridge limiting the groove above is continuous with the inferior border of the neck of the rib; its gives attachment to the *internal intercostal* muscles.

FIG. 108.—THE SEVENTH RIB OF THE LEFT SIDE. (Seen from below.)


TUBERCLE
ARTICULAR PORTION OF TUBERCLE
NECK
HEAD
SUBCOSTAL GROOVE
SHAFT
STERNAL END FOR COSTAL CARTILAGE

The superior border is rounded, and affords attachment to the *internal* and *external intercostal* muscles. The inferior border commences abruptly near the angle, and gives attachment to the *external intercostal* muscles.

The **sternal** end of the shaft is cupped for the reception of the costal cartilage.

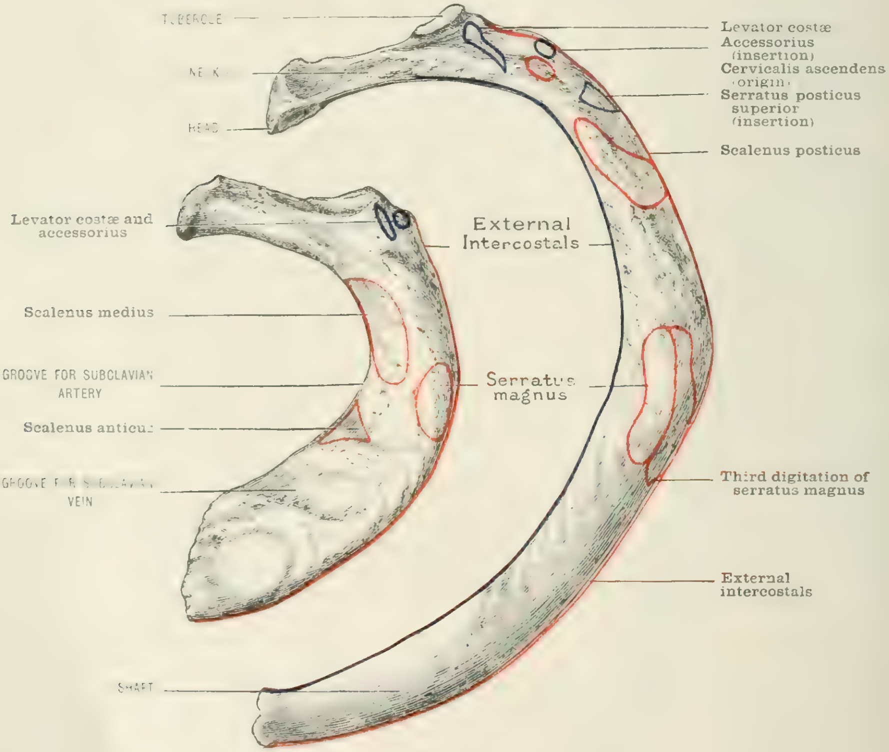
The seventh rib and its costal cartilage give attachment to the following **muscles** :—

Internal intercostals (sixth and seventh).
External intercostals (sixth and seventh).
Levatores costarum (seventh).
Infracostal (when present).
Diaphragm.
Transversalis.
External oblique abdominis.
Rectus abdominis (costal cartilage).
Triangularis sterni (costal cartilage).
Serratus magnus.
Ilio-costalis, or sacro-lumbalis.
Musculus accessorius.
Longissimus dorsi.

It gives attachment to the following **ligaments** :—

Anterior costo-vertebral or costo-central (stellate).
Middle costo-transverse (interosseous).
The capsular.
Superior costo-transverse.
Posterior costo-transverse (rhomboid).
The interarticular.

FIG. 109.—FIRST AND SECOND RIBS.


TUBERCLE
NECK
HEAD
Levator costæ
Accessorius (insertion)
Cervicalis ascendens (origin)
Serratus posticus superior (insertion)
Scalenus posticus
Levator costæ and accessorius
External Intercostals
Scalenus medius
GROOVE FOR SUBCLAVIAN ARTERY
Serratus magnus
Scalenus anticus
GROOVE FOR SUBCLAVIAN VEIN
Third digitation of serratus magnus
External intercostals
SHAFT

Blood-supply.—The ribs are very vascular and derive numerous branches from the intercostal arteries. The branches in the shaft run towards the rib-head. Those of the head and neck take a contrary direction, and run, as a rule, towards the shaft. In the neighbourhood of the tuberosity the vessels seem to run in any direction.

Peculiar ribs.—Several of the ribs differ in many particulars from this general description. They are the first, second, tenth, eleventh, and twelfth.

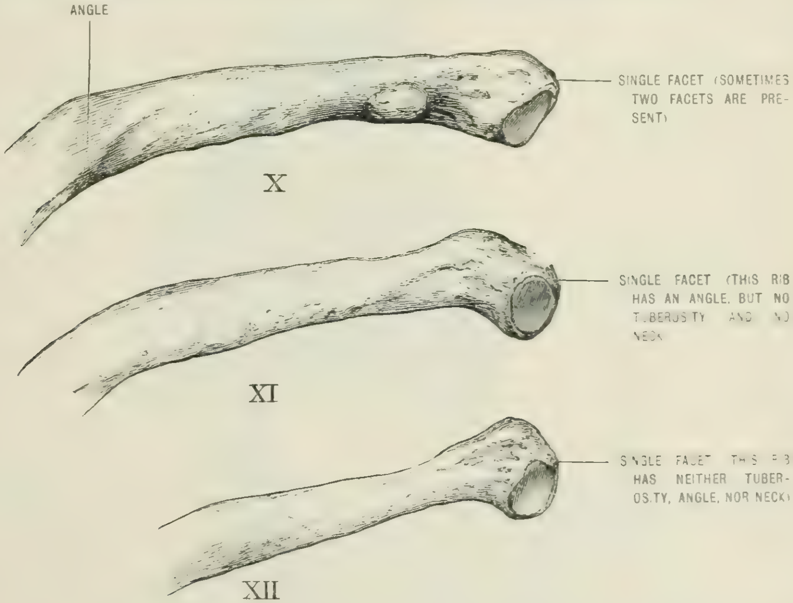
The **first rib** is the broadest and most sharply curved. The head is small, and, as a rule, is furnished with only one articular facet. The tubercle is large and prominent, the neck narrow. The shaft is broad, has no angle, and is curved around a vertical axis only. The upper surface presents two shallow grooves separated near the inner border by a rough surface (Lisfranc's or Scalene tubercle) for the *scalenus anticus* muscle. The groove in front of this surface is for the subclavian vein, the groove behind it is for the subclavian artery. Between the groove for the artery and the angle there is a rough surface for the *scalenus medius* muscle; anterior to this rough surface and close beside the groove is an area from which the first digitation of the *serratus magnus* takes origin. The under surface is smooth and lacks a groove. The outer border is thick, and rounded for the *internal* and *external intercostal* muscles.

The costal cartilage of this rib fuses with the manubrium of the sternum; occasionally the sternal extremity and costal cartilage of this rib are replaced by fibrous tissue. When a well-developed cervical rib is present, the head of the first may present two facets as in a typical rib.

The first rib, with its costal cartilage, gives attachment to the following **muscles** :—

Internal intercostal.
External intercostal.
Levator costæ.
Scalenus anticus.
Scalenus medius.
Subclavius (costal cartilage).
Sterno-hyoid (costal cartilage).
Pectoralis major (costal cartilage).
Serratus magnus.
Musculus accessorius.

FIG. 110.—THE VERTEBRAL ENDS OF TENTH, ELEVENTH, AND TWELFTH RIBS.


ANGLE
SINGLE FACET (SOMETIMES TWO FACETS ARE PRESENT)
X
SINGLE FACET (THIS RIB HAS AN ANGLE, BUT NO TUBEROSITY AND NO NECK)
XI
SINGLE FACET (THIS RIB HAS NEITHER TUBEROSITY, ANGLE, NOR NECK)
XII

Blood-supply.—This is derived mainly from the superior intercostal branch of the subclavian artery.

The **second rib**, like the first, is strongly curved; its posterior angle is faintly marked; and the shaft, like that of the first, can lie flat on the table. It has a prominent anterior angle for the *serratus magnus*.

It gives attachment to the following **muscles** :—

Internal intercostals (first and second).
External intercostals (first and second).
Levator costæ.
Pectoralis major (costal cartilage).
Serratus magnus.
Serratus posticus superior.
Scalenus posticus.
Musculus accessorius.
Cervicalis ascendens.

Blood-supply.—Superior intercostal branch of the subclavian artery, and the first aortic intercostal.

The **tenth rib** has usually a **single facet** on its head. Occasionally a second is present. When this is the case, the ninth thoracic vertebra is not exceptional, and presents two demi-facets.

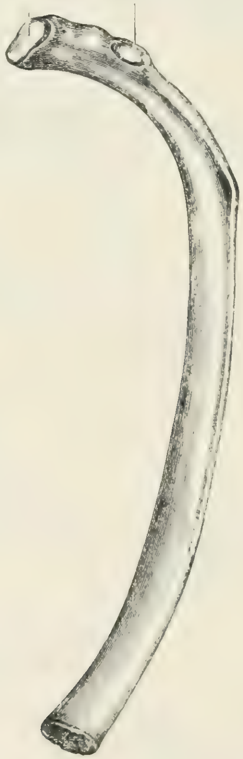
The **eleventh rib** has a **single facet** on the head. The angle is feebly marked, and the subcostal groove shallow. It lacks a neck and tubercle.

The **twelfth rib** has a large head furnished with one facet. The shaft is narrow, and its length extremely variable. It may be as short as 3 cm., or attain a length of 20 cm. (8″).

The **twelfth rib** gives attachment to the following muscles:—

Internal intercostal.
External intercostal.
Levator costæ.
Diaphragm.
Transversalis abdominis.
External oblique.
Internal oblique.
Serratus posticus inferior.
Musculus accessorius.
Sacro-lumbalis or ilio-costalis.
Erector spinæ.
Quadratus lumborum.
Latissimus dorsi.

FIG. 111.—RIB AT PUBERTY.


EPIPHYSIS FOR THE HEAD APPEARS AT FIFTEEN, FUSES AT TWENTY-THREE
EPIPHYSIS FOR TUBERCLE. APPEARS AT FIFTEEN; FUSES AT TWENTY-THREE
THE CARTILAGINOUS SHAFT COMMENCES TO OSSIFY AT THE EIGHTH WEEK OF INTRA-UTERINE LIFE

The **costal cartilages** are bars of hyaline cartilage attached to the anterior extremities of the ribs; they represent **unossified epiphyses.** Like the shaft of a rib, each has an outer and inner surface; the outer surfaces give origin and insertion to large muscles; and the inner surfaces, from the second to the seventh inclusive, are in relation with the *triangularis sterni.* The upper and lower borders serve for the attachment of the *internal intercostal* muscles. The upper seven cartilages, and occasionally the eighth, are connected with the sternum. The first fuses with the manubrium; the remaining six are received in small articular concavities, and retained by means of ligaments. The cartilages of the vertebro-chondral ribs are united to one another and to the seventh costal cartilage by ligaments (sometimes by short vertical bars of cartilage), and those of the vertebral ribs end freely. The inner surfaces of the lower six afford attachment to the *diaphragm* and the *transversalis* muscle.

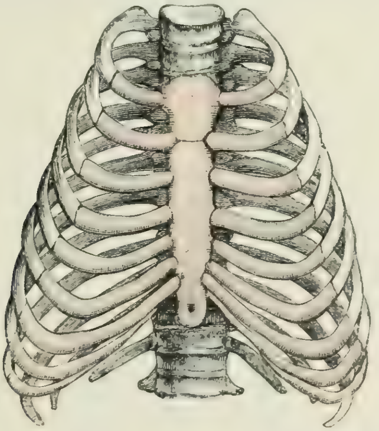
The second, third, fourth, and fifth costal cartilages articulate with the sides of the sternum, at a spot corresponding to the junction of two sternebræ. The sixth and seventh (and eighth when this reaches the sternum) are arranged irregularly. As a rule the sixth lies in a recess in the side of the fifth sternebra; the seventh corresponds to the line of junction of the meso- and metasternum; and the eighth articulates with the metasternum (see fig. 112).

Blood-supply.—The twigs for the costal cartilages are derived from the terminal twigs of the aortic intercostals, and from the internal mammary arteries.

Development.—At the eighth week of intra-uterine life the ribs are cartilaginous. About this date an earthy spot appears near the angle of each rib, and spreads with great rapidity along the shaft, and by the fourth month reaches as far as the costal cartilage; the proportion borne by the rib-shaft to the costal cartilage is about the same at this date as in adult life. Whilst the ribs are in a cartilaginous condition, eight of them reach the sternum; even after ossification has taken place, the costal cartilage of the eighth rib, in many instances, articulates with the sternum as late as the eighth month (fig. 112). This relationship may persist through life, but usually the cartilage retrogresses, and is replaced by ligamentous tissue. About the fifteenth year a secondary centre appears for the head of each rib, and a little later one makes its appearance for the tubercle, except in the tenth, eleventh, and twelfth ribs. The secondary centres fuse with the ribs about the twenty-third year. The rib-shaft increases in length mainly at its line of junction with the costal cartilage.

FIG. 112.—THE THORAX AT THE EIGHTH MONTH.

(On the left side eight cartilages reach the sternum.)



Variations in the Number and Shape of the Ribs

The ribs may be increased in number by addition either at the cervical or lumbar end of the series, but it is extremely rare to find an additional rib or pair of ribs in both the cervical and lumbar regions in the same subject.

Cervical ribs are fairly common; as a rule they are of small size and rarely extend more than a few millimetres beyond the extremity of the transverse process. Occasionally they exceed such insignificant proportions and reach as far as the sternum: between these two extremes many varieties occur. As a rule, the existence of a cervical rib is not detected until the skeleton is macerated; hence we know little of the correlated arrangement of soft parts. In one fortunate case Turner was able to make a thorough dissection of a specimen in which a complete cervical rib existed. Its head articulated with the body of the seventh cervical vertebra and had a stellate ligament. The tubercle was well developed, and articulated with the transverse process. The costal cartilage blended with that of the first thoracic rib, and gave attachment to the costo-clavicular ligament. Between it and the first thoracic rib there was a well-marked intercostal space occupied by intercostal muscles. It received the attachment of the *scalenus anticus* and *medius* muscles, and it was crossed by the subclavian artery and vein. The nerves of the intercostal space were supplied in part by the eighth cervical and first dorsal. The artery of the space was derived from the deep cervical, which, with the superior intercostal, arose from the root of the vertebral. The head of the first thoracic rib in this specimen articulated with the seventh cervical, as well as with the first thoracic vertebra. An interesting fact is also recorded in the careful account of this specimen:—There was no movable twelfth thoracic rib on the same side as this well-developed cervical rib, and the twelfth thoracic vertebra had mammillary and accessory processes, and a strong elongated costal process, and was in linear series with the lumbar transverse processes.

Gruber and Turner from a careful and elaborate study of this question summarise the variations in the cervical rib thus:—It may be very short and possess only a head, neck, and tubercle. When it extends beyond the transverse process, its shaft may end freely or join the first thoracic rib: this union may be effected by bone, cartilage, or ligament. In very rare instances it may have a costal cartilage and join the manubrium of the sternum. Not unfrequently a process, or eminence, exists on the first thoracic rib at the spot when it articulates with a cervical rib.

Lumbar ribs are of less significance than cervical ribs and rarely attain a great length. Their presence is easily accounted for, as they are the differentiated costal elements of the transverse processes. They are never so complete as in cervical ribs, and articulate only with the transverse processes; the head never reaches as far as the body of the vertebra, and there is no neck or tubercle. An extra *levator costæ* muscle is associated with a lumbar rib.

Not the least interesting variation of a rib is that known as the **bicipital rib.** This condition is seen exclusively in connection with the **first thoracic rib.** The vertebral end consists of two limbs which lie in different transverse planes. These bicipital ribs have been especially studied in whales and man. This abnormality is due to the fusion of two ribs, either of a cervical rib with the shaft of the first thoracic; or the more common form, the fusion of the first and second true ribs.

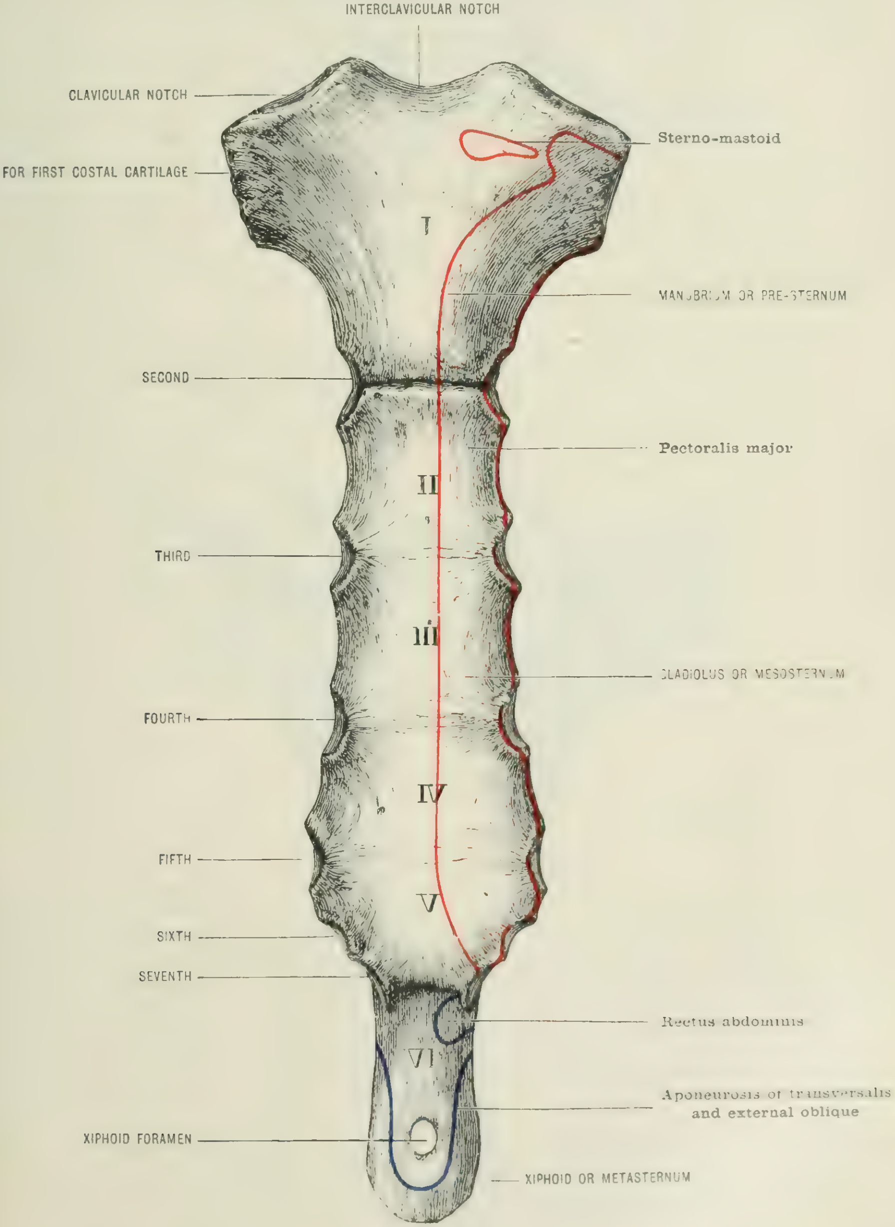
Among unusual variations of ribs should be mentioned the replacement of the costal cartilage and a portion of the rib-shaft by fibrous tissue, a process which occurs as a normal event, during development, in the eighth rib.

Sometimes the shafts of two or more ribs may become united by small quadrilateral plates of bone extending across the intercostal spaces.

The **sternum** is a thin flat bone situated in the anterior wall of the thorax. In the young subject it consists of six pieces, or **sternebræ.** Of these, the four middle fuse together to form the **gladiolus** (mesosternum); the superior remains distinct throughout life as the **manubrium** (pre-sternum); and the lower segment, also distinct until very advanced life, is the **xiphoid** (metasternum). The anterior surface of the adult sternum is convex, and gives origin to the *pectoralis major* muscle of each side; near its superior angle the *sterno-mastoid* muscle arises. This surface is traversed by five lines, indicating the former segmentation of this bone. The posterior surface is concave, and traversed by five lines corresponding to those on the anterior surface. At the upper part it gives origin to the *sterno-hyoid* and *sterno-thyroid* muscles. The posterior surface of the lower four segments gives origin to the *triangularis sterni.* The *xiphoid* is usually perforated; a branch of each internal mammary artery traverses the foramen; and on each side of it a portion of the *diaphragm* is attached. Occasionally the xiphoid is bifid. The superior border presents the **interclavicular notch,** to which the fibres of the interclavicular ligament are attached; this border terminates at each end in an articular notch for the sternal end of the clavicle. The margins of the notch give attachment to the sterno-clavicular ligaments. The lateral borders of the sternum present a series of depressions, which receive the sternal extremities of the costal cartilages of the first seven ribs, and occasionally that of the eighth (see fig. 112). The borders intervening between these depressions or notches are in relation with the *internal intercostal* muscles.

In order to appreciate the nature of these notches, it is advantageous to study the sternum in a young subject. Each typical **sternebra** presents four angles; each angle presents a demi-facet. Between every two sternebræ there is an intersternebral disc; when two sternebræ are in position, each notch for a costal cartilage is formed by a sternebra above and below with an intersternebral disc in the middle, thus repeating the relation of the rib-head to the vertebral centra. Later in life these fuse more or less together, except in the case of the first and second sternebræ, which usually remain separate to the end of life. The first (pre-sternum) is the most modified of all the sternebræ, and differs from them in the fact that the costal cartilage of the first rib is continuous with it, and in the fact that it supports the clavicles. Occasionally a rounded pisiform bone is seen on each side, immediately internal to the articular notch for the clavicle: these are the **episternal** bones. The last sternebra, or xiphoid, is the least developed and, though calcified in old age, rarely ossifies. Its tip is directly continuous with the linea alba, and the base gives slight attachment to the *rectus abdominis* muscle.

FIG. 113.—THE STERNUM. (Anterior view.)


INTERCLAVICULAR NOTCH
CLAVICULAR NOTCH
FOR FIRST COSTAL CARTILAGE
Sterno-mastoid
I
MANUBRIUM OR PRE-STERNUM
SECOND
Pectoralis major
II
THIRD
III
GLADIOLUS OR MESOSTERNUM
FOURTH
IV
FIFTH
V
SIXTH
SEVENTH
Rectus abdominis
VI
Aponeurosis of transversalis and external oblique
XIPHOID FORAMEN
XIPHOID OR METASTERNUM

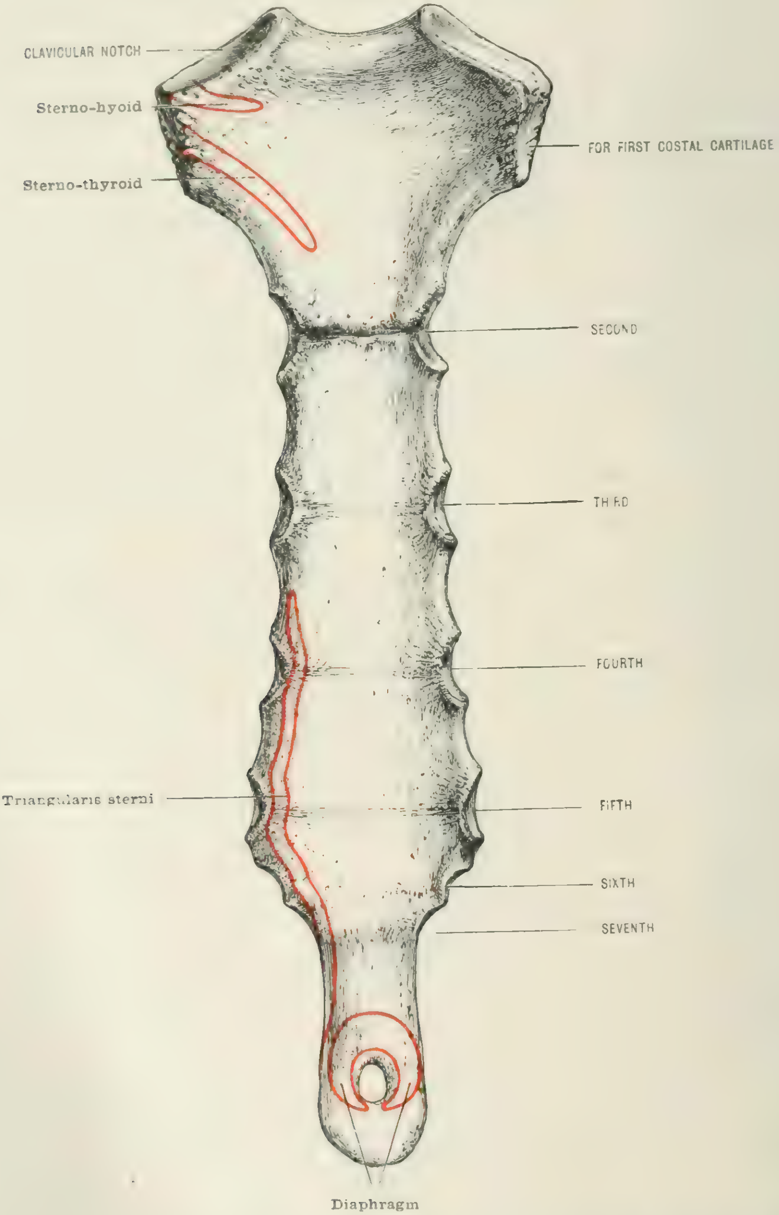
The following **muscles** are attached to the sternum:—

Pectoralis major.
Sterno-cleido-mastoid.
Internal intercostals.
Rectus abdominis.
Triangularis sterni.
Transversalis.
Diaphragm.
Sterno-hyoid.
Sterno-thyroid.

Ligaments.—In addition to the ligaments proper to the costal cartilages, the following require enumeration:—

Interclavicular.
Anterior sterno-clavicular.
Posterior sterno-clavicular.
Interarticular fibro-cartilage.
Linea alba.

Fig. 114.—The Sternum. (Posterior view.)


CLAVICULAR NOTCH
Sterno-hyoid
Sterno-thyroid
FOR FIRST COSTAL CARTILAGE
SECOND
THIRD
FOURTH
Triangularis sterni
FIFTH
SIXTH
SEVENTH
Diaphragm

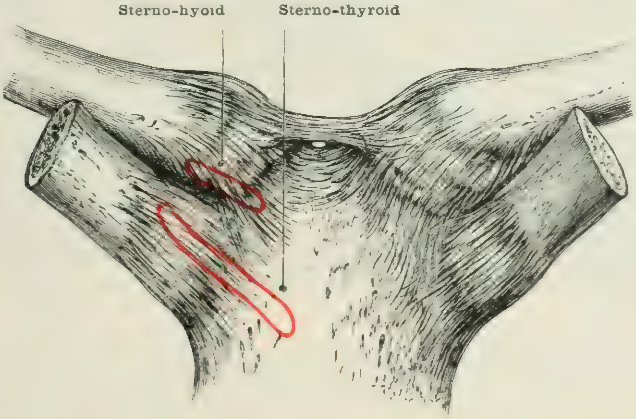
Blood-supply.—The arteries of the sternum are derived mainly from the internal mammary arteries by direct branches termed sternal: many twigs are furnished by the perforating branches of the internal mammary, and also by the terminal twigs of the aortic intercostals.

Development.—The sternum results from the fusion of the ventral ends of the cartilaginous bars which in the early embryo represent the ribs. At first these bars fuse together laterally, and for some time the sternum is represented by two strips of cartilage separated by a median fissure. Very early this gap is bridged over anteriorly. Nine costal cartilages are in relation with the sternum at this stage. Gradually the lateral strips unite with each other to form the mesosternum. The ninth costal cartilage divides: one part remains attached to the sternum and becomes the xiphoid, whilst the end still attached to the rib acquires a new attachment to the eighth cartilage. The ends, still adherent to the sternum, may remain separate and give rise to a bifid metasternum (xiphoid); much more frequently they unite, leaving a small foramen. The eighth cartilage may retain its sternal attachment permanently.

At first the sternum and costal cartilages are continuous; a joint soon forms between the pre-sternum and mesosternum. Gradually joints arise between the costal cartilages and the sternum (except in the case of the first). The division of the mesosternum into sternebræ is a still later process, and arises during the process of ossification.

Ossification.—The transformation of the sternum into bone is a slow and irregular process. The pre-sternum (manubrium) has a mesial nucleus about the sixth month of intra-uterine life; later, several smaller accessory centres may appear. The mesosternum usually ossifies from seven centres. The second sternebra ossifies from a single median nucleus about the eighth month. Below this, three pairs of ossific nuclei appear, and they may remain long separate. Of these, two pairs for the third and fourth sternebræ are visible at birth. The pair for the fifth sternebra make their appearance towards the end of the first year. The various lateral centres unite in pairs, and at the sixth year the sternum consists of six sternebræ, the lowest (metasternum) being cartilaginous. Gradually the four pieces representing the mesosternum fuse with one another, and at twenty-five they form a single piece, but exhibit, even in advanced life, traces of their original separation.

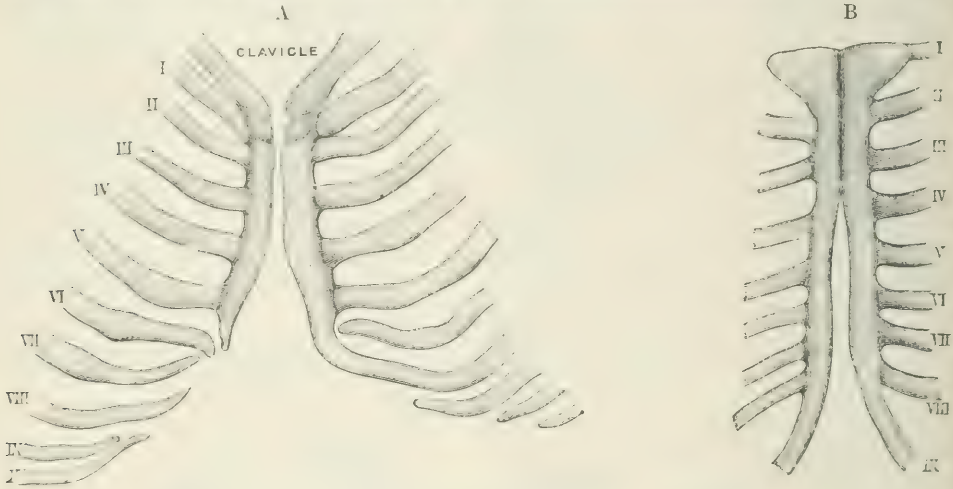
FIG. 115.—POSTERIOR SURFACE OF THE MANUBRIUM (PRE-STERNUM), WITH STERNAL ENDS OF CLAVICLE AND THE FIRST COSTAL CARTILAGE.



The metasternum is always imperfectly ossified, and does not ankylose with the mesosternum till after middle life. The pre-sternum and mesosternum rarely fuse. The dates given above for the various nuclei are merely approximate, for they are extremely variable, not only in appearing, but in their number. The same remark applies also to the age at which the various segments ankylose; hence the sternum affords very uncertain data as to age.

Abnormalities of the sternum.—The mode of development of the sternum as described above is of importance in connection with some deviations to which it is occasionally subject. At an early period it consists of two lateral halves; in some rare instances these have failed to unite, and thus give rise to the anomaly of a completely cleft sternum. The union of the two halves may occur in the region of the manubrium, but fail below this point; in some instances the upper and lower segments have duly coalesced with the opposite side, but union has failed in the middle segments. The clefts resulting from these failures of coalescence are in many instances so small as not to be of any moment, and not even recognised until the skeleton has been prepared. In a few individuals they have been so extensive as to allow the pulsation of the heart to be perceptible to the hand, and even to the eye, through the skin covering the defect in the bone.

FIG. 116.—TWO STAGES IN THE FORMATION OF THE CARTILAGINOUS STERNUM. (After Ruge.)



A common variation in the sternum is asymmetry of the costal cartilages. Instead of corresponding, the cartilages may articulate with the sternum in an alternating manner. The cause of this asymmetry is not known.

THE THORAX

The thorax is a bony cage of conical shape, formed by the thoracic vertebræ, the ribs with their costal cartilages, and the sternum. The thorax is compressed antero-posteriorly so that it measures less in the sagittal than in the transverse axis; it is also deeper posteriorly than anteriorly. Its posterior boundaries are formed by the thoracic vertebræ and the ribs as far outward as their angles; the backward curve of the ribs produces on each side of the vertebræ a deep furrow, the **costo-vertebral groove,** in which the *erector spinæ* muscle and its subdivisions are lodged.

The anterior boundary is formed by the sternum and costal cartilages. This surface is slightly convex, and has a slight inclination forwards in its lower part.

The lateral boundaries are formed by the ribs from their angles to the costal cartilages.

The top of the thorax presents an elliptical aperture, the **thoracic inlet,** which measures, on an average, 12·5 cm. (5″) transversely, and 6·2 cm. (2½″) in its sagittal axis.

The lower opening of the thorax is very irregular, and forms two curved lines ascending from the last rib to the lower border of the gladiolus (mesosternum). These two borders form the **subcostal angle,** and the xiphoid (metasternum)

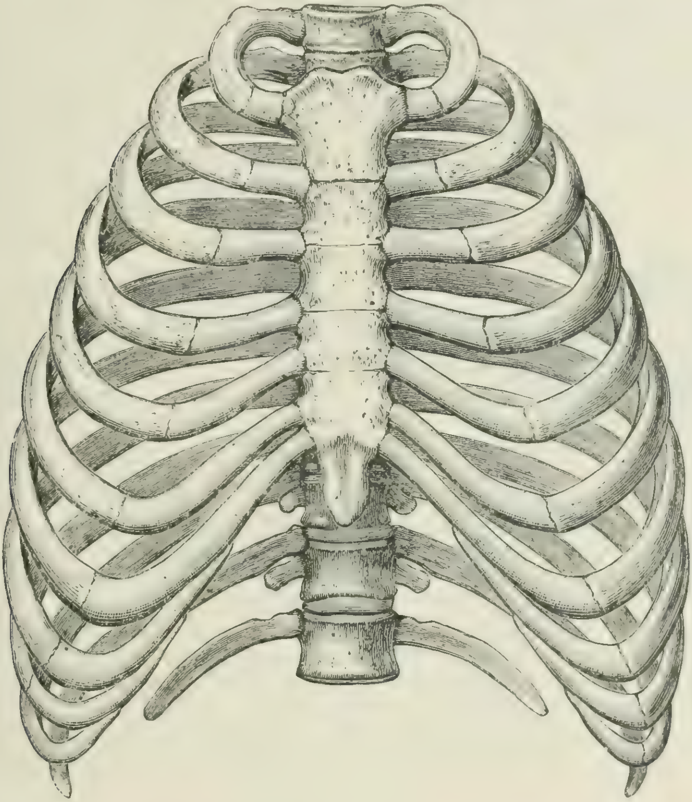


FIG. 117.—THE THORAX. (Front view.)

projects into the middle of it. The intervals between the ribs are the *intercostal spaces,* and are eleven in number on each side.

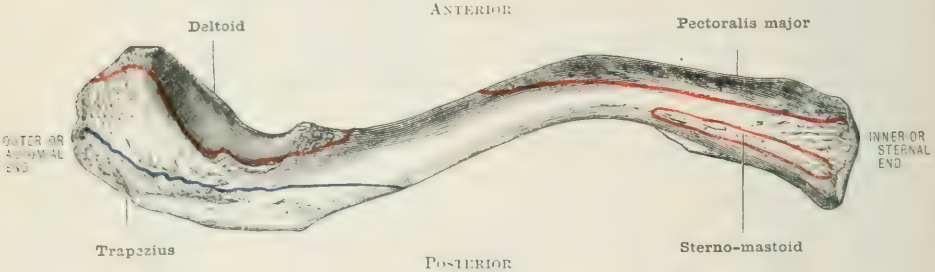
THE CLAVICLE

The clavicle is a rod of bone passing from the top of the sternum to the acromion process of the scapula. It presents two curves: an inner, with the convexity directed forwards; and an outer, the smaller, with the convexity directed backwards. The clavicle consists, for descriptive purposes, of an outer flattened, and an inner prismatic portion.

The **outer third** has two surfaces and two borders. The **superior surface** looks directly upwards, and affords attachment to the *trapezius* muscle posteriorly, and the *deltoid* anteriorly; a small tract intervening between the muscles is subcutaneous. The **inferior surface** is rough, and at its most posterior part presents the **tuberosity** (or conoid tubercle) of the clavicle; it overhangs the coracoid process and gives attachment to the conoid ligament. From the tuberosity a ridge, **the oblique line,** runs outwards and forwards; to it, the trapezoid ligament is attached. The **anterior border** is thin; presents often a small prominence, the *deltoid tubercle*, and gives origin to the *deltoid* muscle. The **posterior border** is thick and rounded; into it the *trapezius* is inserted.

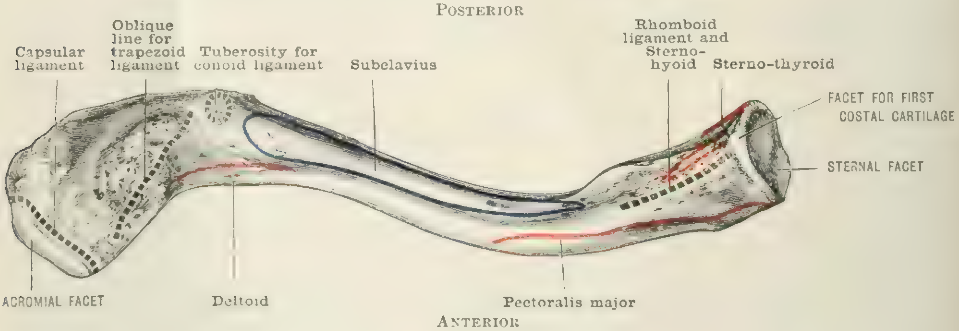
The inner two-thirds is prismatic in form; it has three surfaces and three borders. Of these, the **anterior surface** is convex and presents near the sternal end a rough surface for the clavicular portion of the *pectoralis major*, and a rough surface above for the *sterno-cleido-mastoid*. Near the middle of the shaft it is smooth and covered by the thin *platysma myoides;* sometimes a small canal passes at right angles through this surface of the clavicle; it is traversed by a cutaneous branch from the cervical plexus. The **posterior surface** is concave, and forms an arch over the brachial plexus and subclavian artery.

FIG. 118.—THE LEFT CLAVICLE. (Superior surface.)


ANTERIOR
Deltoid
Pectoralis major
OUTER OR ACROMIAL END
INNER OR STERNAL END
Trapezius
Sterno-mastoid
POSTERIOR

The **inferior surface** commences externally as a groove for the *subclavius*, the floor of the groove being continuous with the inferior surface of the outer third of the clavicle, and frequently presents the orifice of the nutrient foramen. Internally, this groove becomes very narrow, and runs on to the rough surface for the rhomboid ligament. On the sternal side of the rhomboid impression there is often a facet where the clavicle plays on the first costal cartilage. Near this facet the *sterno-hyoid* muscle finds an attachment, and occasionally the *sterno-thyroid*. Of the three **borders,** the **superior** separates the anterior and posterior surfaces; it is faintly marked towards the sternal end; externally, it becomes continuous with the posterior border of the outer third. The **anterior border** separates the anterior and inferior surfaces; it is continuous with the anterior border of the flattened portion. The **posterior border** separates the inferior and posterior surfaces, and forms the posterior lip of the groove for the *subclavius;* it begins at the conoid tubercle, and ends at the **rhomboid depression.** The **inner** or **sternal** end of the clavicle is broad and expanded; it plays upon a fibro-cartilage interposed between it and the clavicular facet of the manubrium of the sternum, and its borders are rough for the attachment of the sterno-clavicular and inter-clavicular ligaments. The **acromial,** or outer end, presents a smooth articular facet, directed slightly downwards for the acromion; its edges, especially the superior, are rough for the attachment of the acromio-clavicular ligaments.

FIG. 119.—THE LEFT CLAVICLE. (Inferior surface.)


POSTERIOR
Capsular ligament
Oblique line for trapezoid ligament
Tuberosity for conoid ligament
Subclavius
Rhomboid ligament and Sterno-hyoid
Sterno-thyroid
FACET FOR FIRST COSTAL CARTILAGE
STERNAL FACET
ACROMIAL FACET
Deltoid
Pectoralis major
ANTERIOR

The following **muscles** are attached to the clavicle:—

Sterno-cleido-mastoid.
Pectoralis major.
Subclavius.
Deltoid.
Trapezius.
Sterno-hyoid.
Sterno-thyroid (occasionally).

Ligaments:—

Interclavicular.
Interarticular (sternal).
Capsular (sterno-clavicular).
Rhomboid or costo-clavicular.
Capsular (acromio-clavicular).
Interarticular (acromio-clavicular).
Conoid.
Trapezoid.
Costo-coracoid membrane.
Deep cervical fascia.

Blood-supply.—The nutrient artery is a branch of the suprascapular; it enters the bone on the under surface of the shaft near the middle of the subclavian groove. It is directed towards the acromial end. The acromial end of the clavicle receives numerous branches from the acromio-thoracic artery, and twigs from the arteries in the muscles attached to it.

Ossification.—The clavicle is ossified from two centres. The primary nucleus appears in the sixth week of embryonic life in the tissue immediately overlying the cartilaginous pre-coracoid bar (see p. 115). The clavicle begins as a membrane-bone, but the ossification quickly extends into the underlying cartilage; it is therefore a dermal splint engrafted on cartilage. About the seventeenth year a secondary nucleus appears at the sternal end. Consolidation is complete by the twentieth year.

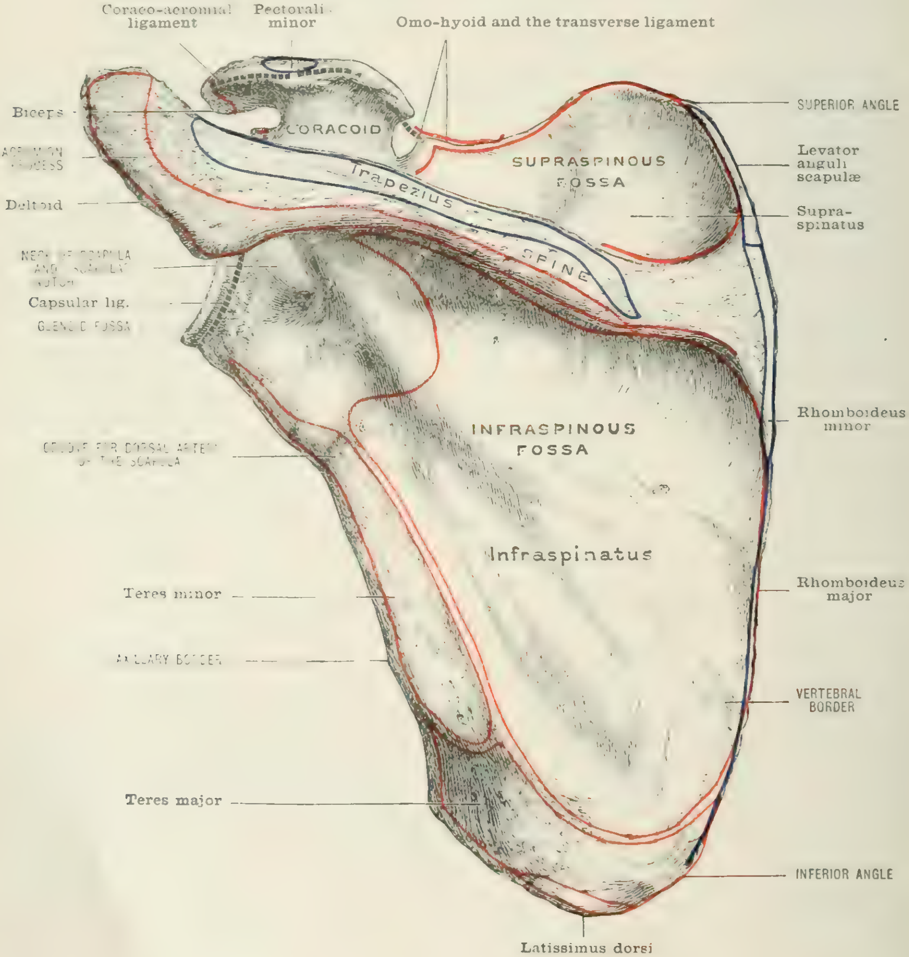
THE SCAPULA

The scapula is a large flat bone, triangular in shape, situated on the posterior aspect of the thorax, and resting on the ribs from the second to the seventh. Of its two surfaces the **anterior** is deeply concave, forming the **subscapular fossa**, which is marked by several ridges commencing at the posterior border of the bone and passing obliquely upwards; these ridges divide this surface into several shallow grooves from which the *subscapularis* muscle takes origin: the highest groove is the deepest. The outer third of this surface is smooth, and overlapped by the *subscapular* muscle: the superior and inferior angles are somewhat triangular, and connected by a narrow ridge of bone along the posterior border. This ridge and its terminal surfaces serve for the insertion of the *serratus magnus.*

The **posterior surface**, or **dorsum**, is generally convex: it is unequally divided by a prominent ridge of bone, the **spine.** The hollow above the spine is the **supraspinous fossa,** and lodges the *supra-spinatus* muscle. The part below the spine is the **infraspinous fossa**; it is larger than the supraspinous fossa, and is limited inferiorly by a ridge which runs from the glenoid fossa backwards to join the posterior border a short distance above the inferior angle. To this **oblique ridge** the stout aponeurosis is attached which separates the *teres major* and *teres minor* muscles from the *infra-spinatus* muscle. The *infra-spinatus* arises from the inner two-thirds of the infraspinous fossa, and overlaps the outer third. The supra- and infraspinous fossæ communicate with each other around the outer end of the spine; this part corresponds to the **neck** of the scapula, and the groove is the **scapular notch**; it transmits the suprascapular nerve and artery from one fossa to the other. The surface of bone below the oblique ridge presents two, and occasionally three, facets for muscles: the long narrow outer one is for the origin of the *teres minor;* this is crossed near its middle by a groove for the dorsal artery of the scapula. The second facet is broader, and gives attachment to the *teres major* muscle. In bones from a muscular subject the third facet, quite at the inferior angle, is for a few fibres of the *latissimus dorsi*.

The **spine** commences at the posterior border of the scapula by a broad triangular surface: it then crosses the dorsal surface obliquely to the glenoid fossa, becoming more prominent as it passes outwards till it reaches the neck of the scapula; from this point it forms the overhanging **acromion process.** The spine presents a superior surface which gives origin to the *supra-spinatus* muscle, and an inferior surface which affords origin to the *infra-spinatus* muscle. It has a prominent crest, which is continuous posteriorly with the vertebral border, and, at its commencement, is smooth for a bursa between it and the *trapezius*. The **crest** is subcutaneous, and presents two lips—a superior for the insertion of the *trapezius*, and an inferior lip for the origin of the *deltoid*. The crest is continued into the **acromion process.**

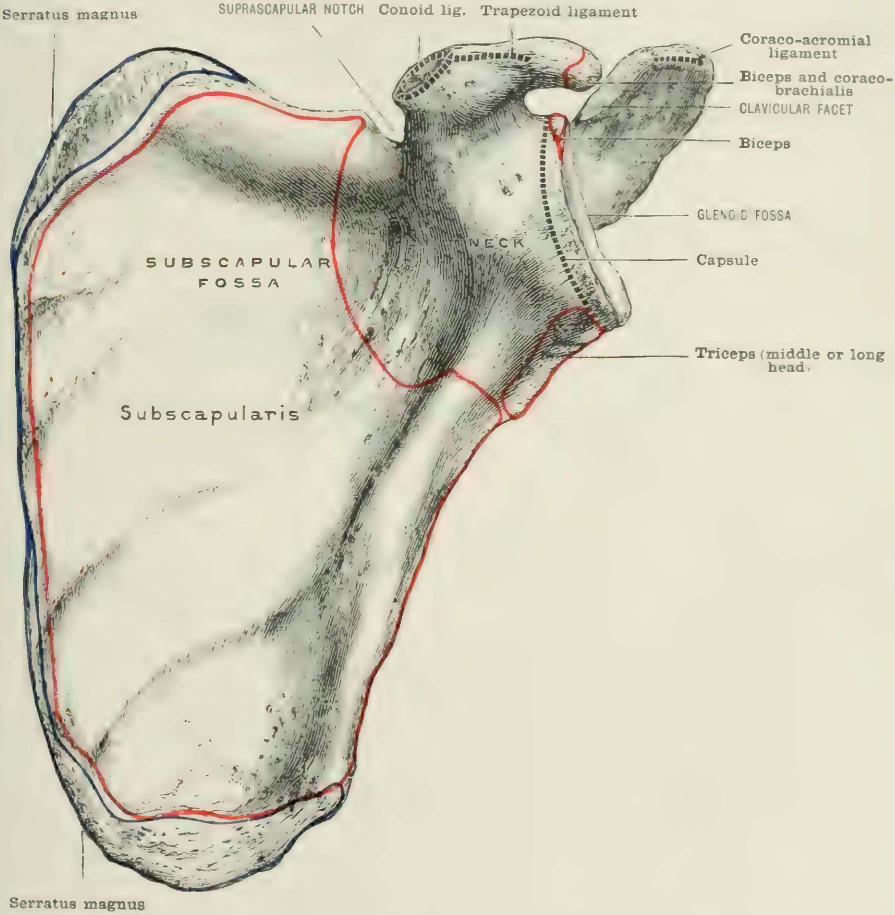
FIG. 120.—THE LEFT SCAPULA. (Dorsal surface.)


Coraco-acromial ligament
Pectoralis minor
Omo-hyoid and the transverse ligament
Biceps
ACROMION PROCESS
Deltoid
NECK OF SCAPULA AND SCAPULAR NOTCH
Capsular lig.
GLENOID FOSSA
GROOVE FOR DORSAL ARTERY OF THE SCAPULA
Teres minor
AXILLARY BORDER
Teres major
Latissimus dorsi
CORACOID
Trapezius
SPINE
SUPRASPINOUS FOSSA
INFRASPINOUS FOSSA
Infraspinatus
SUPERIOR ANGLE
Levator anguli scapulæ
Supra-spinatus
Rhomboideus minor
Rhomboideus major
VERTEBRAL BORDER
INFERIOR ANGLE

The acromion process forms the summit of the shoulder, and presents two surfaces, two borders, and a tip. The upper surface affords origin at its posterior part to a portion of the *deltoid*. The under surface is concave and smooth. Its inner border, a continuation of the superior lip of the crest, receives the *trapezius*, and presents near the tip a small articular facet for the outer end of the clavicle; the edges of the facet are rough for the acromio-clavicular ligaments. The outer border is continuous with the inferior lip of the crest, with which it forms an angle; it gives origin to the *deltoid*. The tip of the acromion affords attachment to the coraco-acromial ligament.

Of the three **borders** presented by the scapula, the external, or **axillary,** is the thickest, and extends from the posterior inferior angle to the lower margin of the glenoid cavity. Near its junction with the glenoid cavity there is a rough surface, from which the long head of the *triceps* arises; below this is the groove for the dorsal artery of the scapula. The *subscapularis* muscle encroaches on this border from the anterior surface, and the *teretes* from the posterior aspect. The **posterior,** or **vertebral, border,** sometimes called the **base,** is the longest; it extends from the **posterior superior** to the **posterior inferior angle.** It is very narrow, but

FIG. 121.—THE LEFT SCAPULA. (Ventral surface.)


Serratus magnus
SUPRASCAPULAR NOTCH
Conoid lig.
Trapezoid ligament
Coraco-acromial ligament
Biceps and coraco-brachialis
CLAVICULAR FACET
Biceps
GLENOID FOSSA
Capsule
NECK
SUBSCAPULAR FOSSA
Subscapularis
Triceps (middle or long head)
Serratus magnus

affords attachment to three muscles: namely, the *levator anguli scapulæ* above the spine; the *rhomboideus minor* on a level with the spine; and the *rhomboideus major*, through the intervention of a fibrous arch from the spine to the inferior angle. The **superior border** is the shortest and thinnest, ending externally in the **coracoid process.** At the base of the coracoid is the **suprascapular notch** to the edges of which the transverse ligament is attached. Not unfrequently the notch is replaced by a **suprascapular foramen.** This notch or foramen transmits the suprascapular nerve, and occasionally the suprascapular artery, but as a rule the artery passes over the ligament. From the adjacent borders of the notch and from the ligament, the *omo-hyoid* takes origin. The **anterior angle** of the scapula is formed by the **glenoid cavity.** This cavity is shallow and pyriform, with its major axis vertical: the lower end is the broader; the upper end or apex gives origin to the long tendon of the *biceps*. The margins are raised, and afford attachment to the glenoid ligament. In the recent state, the cavity is covered with hyaline cartilage, and forms an articular fossa for the head of the humerus. The margin is somewhat defective where it is overarched by the acromion. The circumference is rough for the attachment of the capsular ligament. Beyond this is a narrow constricted portion, called the **neck of the scapula.**

Projecting upwards from the neck is the **coracoid process,** a prominence of bone anterior to, but parallel with, the acromion. It consists of two parts—vertical and horizontal. The vertical part is compressed from within outwards; it is continuous above with the horizontal part and below with the neck of the scapula; its outer border lies above the glenoid cavity and gives attachment to the coraco-humeral ligament, and its inner border which forms the outer boundary of the suprascapular notch gives attachment to the suprascapular ligament; its anterior and posterior surfaces are in relation with the *subscapularis* and *supraspinatus* respectively. The horizontal part runs forwards and outwards; it is compressed from above downwards; its inner extremity gives attachment to the conoid ligament, and its outer extremity, or apex, is for the attachment of the short head of the *biceps* and the *coraco-brachialis;* the *pectoralis minor* is attached to part of the anterior border and the upper surface, and the postero-internal part of the upper surface is occupied by the trapezoid ligament. The posterior border gives attachment to the coraco-acromial ligament.

Muscles.—The following are attached to the scapula:—

Supra-spinatus.
Infra-spinatus.
Subscapularis.
Teres major.
Teres minor.
Omo-hyoid.
Pectoralis minor.
Serratus magnus.
Latissimus dorsi.
Trapezius.
Rhomboideus major.
Rhomboideus minor.
Levator anguli scapulæ.
Biceps.
Coraco-brachialis.
Triceps (long head).
Deltoid.

Ligaments :—

Conoid.
Trapezoid.
Costo-coracoid membrane.
Costo-coracoid ligament.
Capsular (acromio-clavicular).
Coraco-acromial.
Suprascapular (transverse).
Capsular (shoulder-joint).
Coraco-humeral.
Gleno-humeral.
Glenoid.
Rhomboid loop.
Spino-glenoid or inferior transverse.

Blood-supply.—The scapula is supplied by the following arteries:—Twigs from the subscapular artery and from the subscapular branch of the suprascapular enter the bone on the anterior surface. The dorsal artery of the scapula distributes branches in the infraspinous, whilst the suprascapular artery supplies the supraspinous fossa, the spine, the glenoid fossa, and sends branches into the infraspinous fossa. The acromion is supplied by branches of the acromio-thoracic artery.

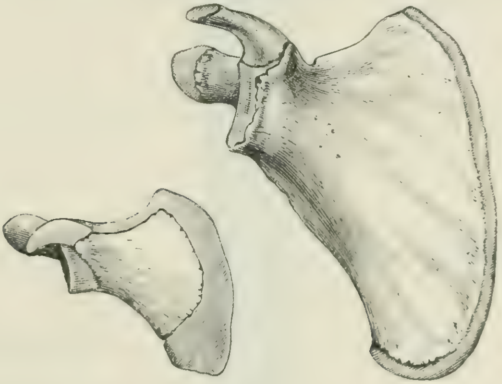
Ossification.—The scapula is ossified from seven centres. Two may be considered as **primary,** and the remainder as **secondary** nuclei. The centre for the body appears in a plate of cartilage near the neck of the scapula about the eighth week of intra-uterine life, and quickly forms a triangular plate of bone, from which the spine appears as a slight ridge about the middle of the third month. At birth the glenoid fossa and part of the scapular neck, the acromion, coracoid, and vertebral border are cartilaginous. During the first year a nucleus appears for the coracoid, and at the tenth year a second centre appears for the base of the coracoid and the upper part of the glenoid cavity.

During the fifteenth year the coracoid is ankylosed to the scapula, and the secondary centres appear. Two nuclei are deposited in the acromial cartilage, and fuse to form the acromion, and join the spine at the twentieth year. This union of the acromion and spine may be fibrous, hence the acromion is often found separate in macerated specimens. The cartilage along the vertebral border ossifies from two centres: one in the middle, and one at the posterior inferior angle. A thin scale may occasionally be detected at the tip of the glenoid fossa.

Morphology.—It is impossible to comprehend the significance of the scapular nuclei without considering briefly the morphology of the shoulder (pectoral) girdle.

In its most generalised form the shoulder girdle consists of cartilage, which is disposed in three parts. Of these, a dorsal segment represents the scapula and a ventral bar, reaching to the sternum, represents the coracoid. The meeting place of the coracoid and scapula is the glenoid fossa. Anterior to the coracoid there is a third piece, more or less parallel with the coracoid, named the pre-coracoid. The human shoulder girdle is modified from the type form, mainly in the suppression of the pre-coracoid and, in part, of the coracoid. The suppression is brought about by the clavicle, which commences to ossify in the membrane overlying the pre-coracoid; it then invades and replaces the cartilage.

FIG. 122.—OSSIFICATION OF THE SCAPULA.



The Scapula at the third year, showing the coracoid element. (Anterior view.)

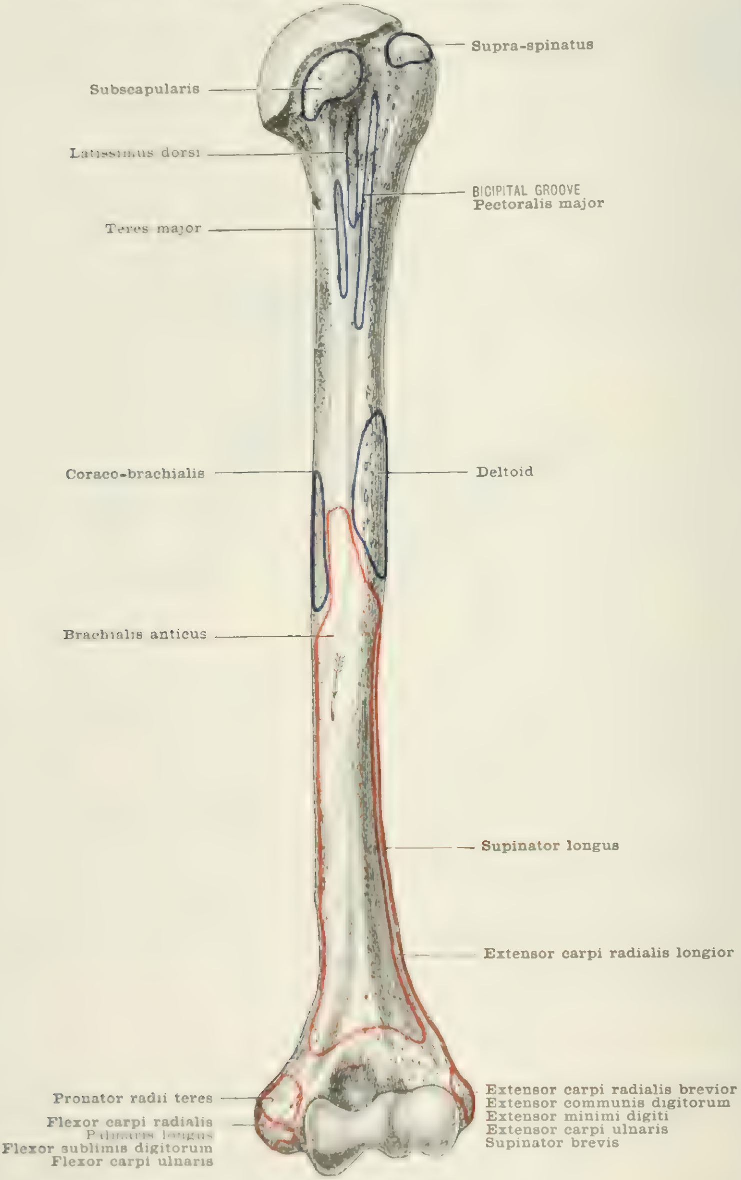
The Scapula at birth. (Anterior view.)

The scapular end of the coracoid ossifies and becomes the coracoid process of the scapula; the ventral end degenerates to form the costo-coracoid ligament, which lies in the free border of the membrane of that name. The dorsal cartilage ossifies and becomes the scapula; the large tract of cartilage on the vertebral border of the young scapula represents the large suprascapular cartilage of batrachians. The suprascapular notch indicates the line of union of scapular and coracoid elements. In the embryo the notch is bridged over by cartilage, which may ossify or become ligament.

THE HUMERUS

The humerus is the longest bone of the upper limb. Its upper extremity presents a hemispherical surface covered with cartilage, and known as the **head.** The head articulates with the glenoid cavity of the scapula, and is directed upwards, inwards, and backwards. Below the articular surface, the bone is rough and constricted, constituting the **anatomical neck.** To the outer side of the head are two tuberosities, separated by the bicipital groove. The **greater tuberosity** is the higher and more posterior; it is marked by three facets for the insertion of muscles: an upper one for the *supra-spinatus*, a middle for the *infra-spinatus*, and an inferior for the *teres minor*. The **lesser tuberosity** is the more prominent; it serves for the insertion of the *subscapularis*. The furrow between the tuberosities lodges the long tendon of the biceps, extends downwards in the axis of the humeral shaft, and, gradually becoming shallower, ends near the junction of the upper and middle third of the bone. The margins of this, the **bicipital groove**, are called **lips**, and afford attachment to muscles. The *pectoralis major* occupies the whole length of the outer lip. The inner lip receives, below, the *teres major*, and above, the *latissimus dorsi*; the tendon of the latter muscle is also attached to the floor of the groove. Between the tuberosities, the transverse humeral ligament converts

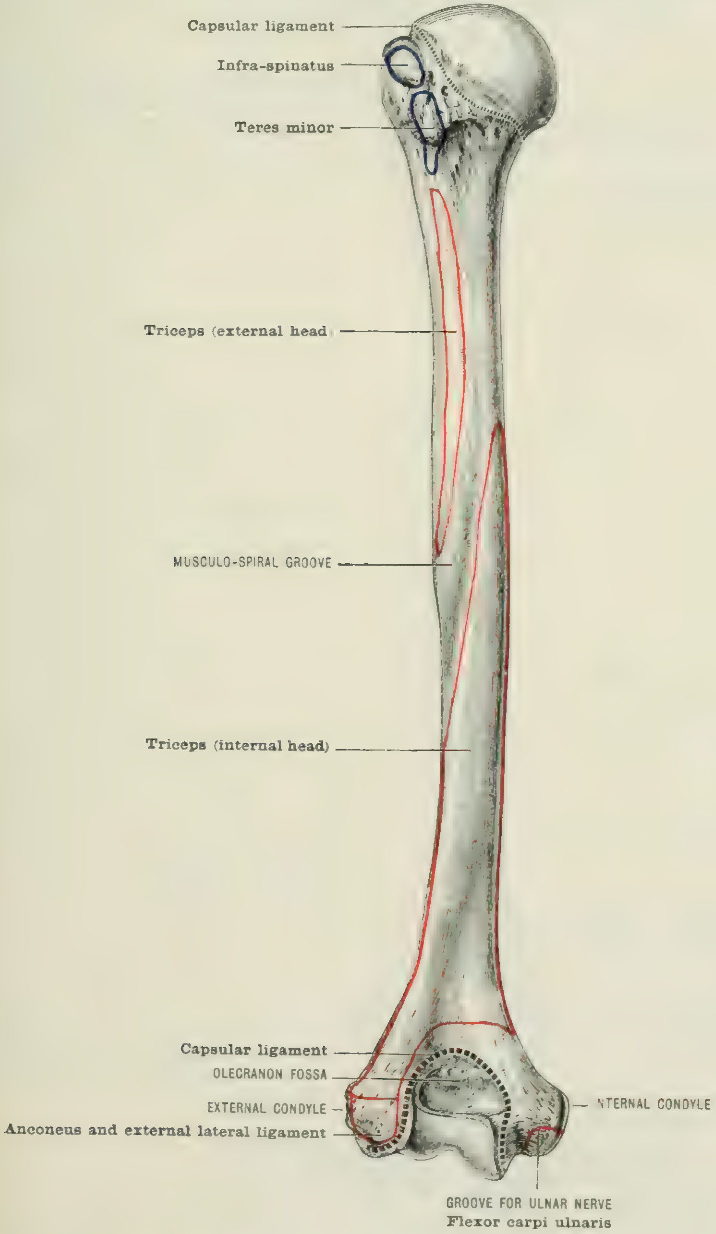
FIG. 123.—THE LEFT HUMERUS. (Anterior view.)


Supra-spinatus
Subscapularis
Latissimus dorsi
BICIPITAL GROOVE
Pectoralis major
Teres major
Coraco-brachialis
Deltoid
Brachialis anticus
Supinator longus
Extensor carpi radialis longior
Pronator radii teres
Flexor carpi radialis
Palmaris longus
Flexor sublimis digitorum
Flexor carpi ulnaris
Extensor carpi radialis brevior
Extensor communis digitorum
Extensor minimi digiti
Extensor carpi ulnaris
Supinator brevis

the groove into a canal. In addition to the long tendon of the biceps and its tube of synovial membrane, the groove transmits a branch of the anterior circumflex artery. The constriction immediately below the tuberosities is the **surgical neck.**

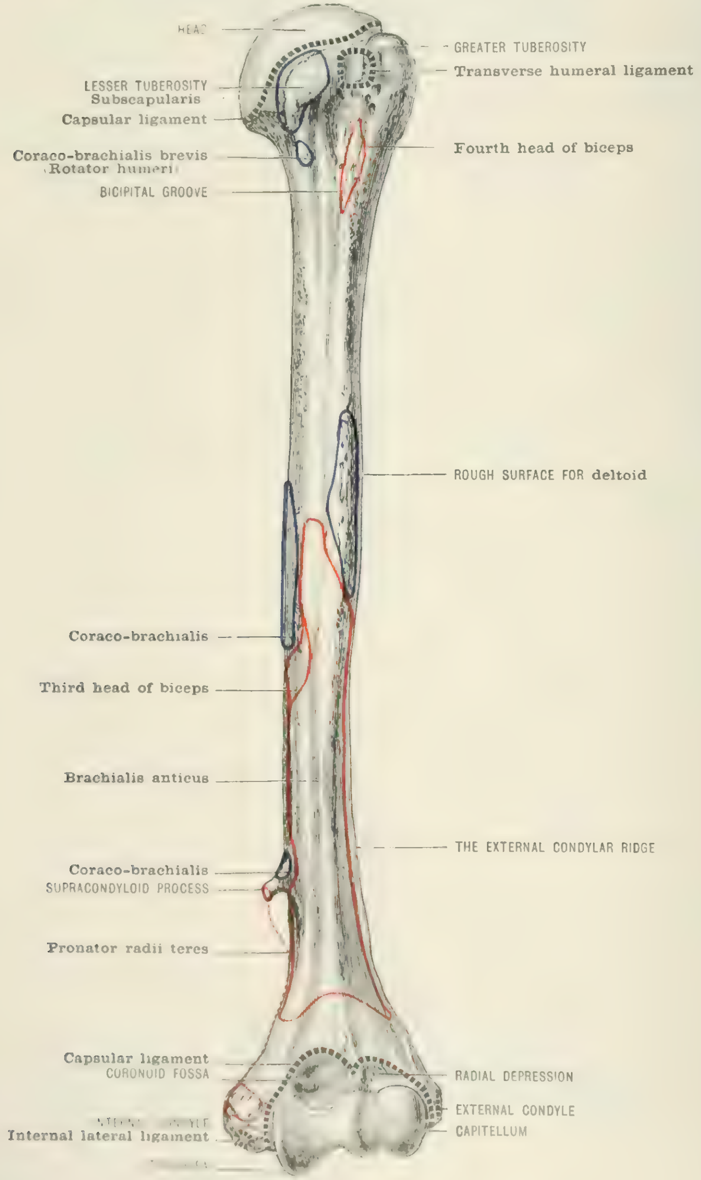
The **shaft** is prismatic in its upper third, but flattened below. Three borders and three surfaces may be recognised. The **anterior border** commences at the greater tuberosity, as the anterior or outer lip of the bicipital groove, and, passing downwards, skirts the radial side of the coronoid fossa, to become continuous with the ridge separating the capitellum and trochlea. The **radial** or **outer** border extends from the posterior border of the greater tuberosity to the radial condyle. This border is not well marked in the upper part of the shaft; near the middle it is

FIG. 124.—THE LEFT HUMERUS. (Posterior view.)


Capsular ligament
Infra-spinatus
Teres minor
Triceps (external head)
MUSCULO-SPIRAL GROOVE
Triceps (internal head)
Capsular ligament
OLECRANON FOSSA
EXTERNAL CONDYLE
Anconeus and external lateral ligament
INTERNAL CONDYLE
GROOVE FOR ULNAR NERVE
Flexor carpi ulnaris

interrupted by the **musculo-spiral groove**; the lower half is termed the **external condylar ridge**, and affords attachment to the *supinator longus* and *extensor carpi radialis longior* muscles, and the external intermuscular septum. The **ulnar or internal border** commences at the lesser tuberosity, as the inner lip of the bicipital groove, and extends downwards to the ulnar (internal) condyle. Near its centre

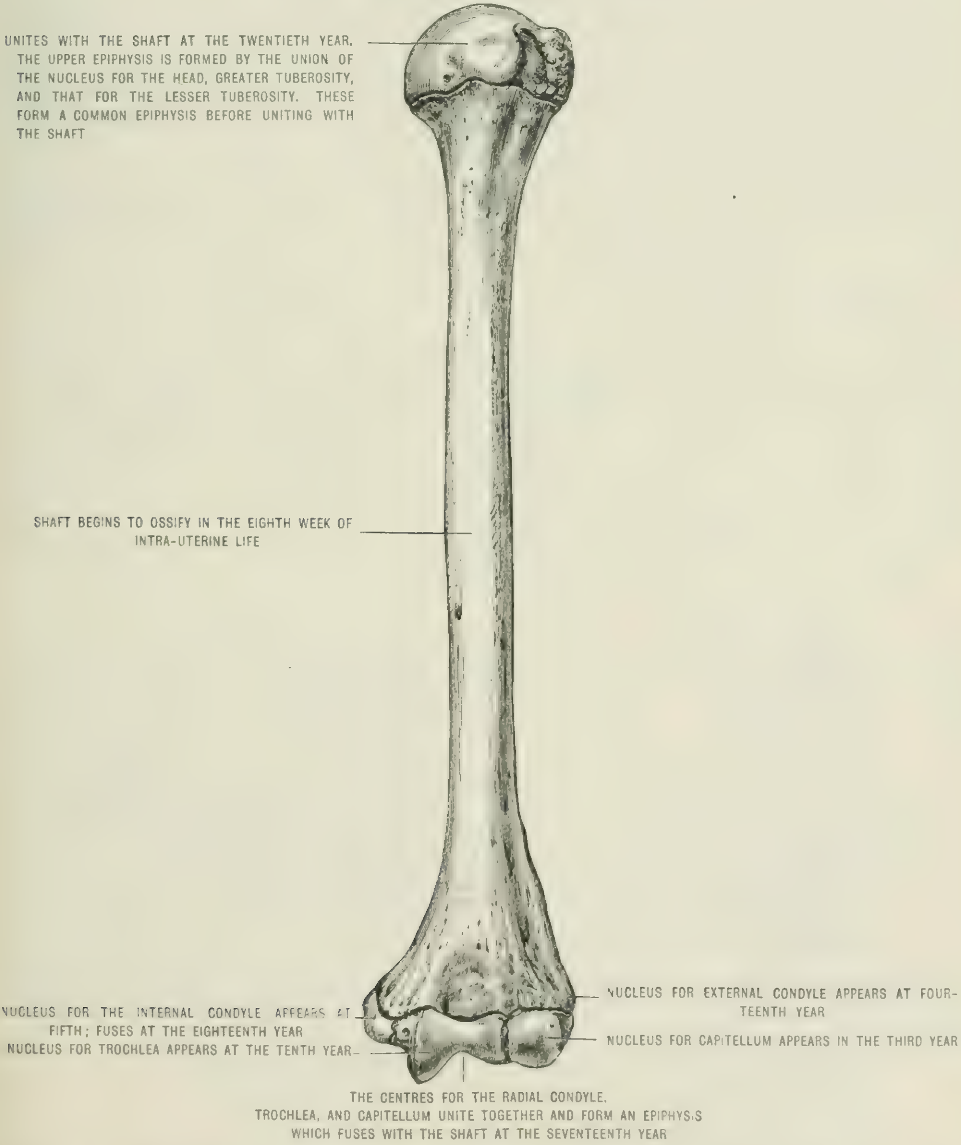
Fig. 125.—The Left Humerus with a Supracondyloid Process and some Irregular Muscle Attachments. (Anterior view.)


HEAD
GREATER TUBEROSITY
Transverse humeral ligament
LESSER TUBEROSITY
Subscapularis
Capsular ligament
Fourth head of biceps
Coraco-brachialis brevis
(Rotator humeri)
BICIPITAL GROOVE
ROUGH SURFACE FOR deltoid
Coraco-brachialis
Third head of biceps
Brachialis anticus
THE EXTERNAL CONDYLAR RIDGE
Coraco-brachialis
SUPRACONDYLOID PROCESS
Pronator radii teres
Capsular ligament
CORONOID FOSSA
RADIAL DEPRESSION
EXTERNAL CONDYLE
INTERNAL CONDYLE
CAPITELLUM
Internal lateral ligament

is a ridge for the insertion of the *coraco-brachialis*, and below this the foramen for the nutrient artery.

The three borders considered above bound three surfaces. The **external surface** lies between the anterior and radial borders. Near its middle is a rough impression for the insertion of the *deltoid*; somewhat lower is the termination of the musculo-spiral groove. The **internal surface** lies between the anterior and ulnar borders. The lower halves of the internal and external surfaces afford origin to the *brachialis anticus* muscle. The **internal surface** usually presents, about 5 cm. (2″) above the ulnar condyle, an elongated rough surface. This is the **supracondyloid ridge**; it is occasionally replaced by a prominent spine of bone, the **supracondyloid process** (fig. 125), from which a band of fibrous tissue extends to the ulnar condyle, forming a ring, transmitting the median nerve and the brachial artery. The nerve is not always accompanied by the artery; in some instances of high division of the brachial the foramen transmits the interosseous artery. The process gives origin to the *pronator radii teres*, and sometimes affords insertion to a part of the *coraco-brachialis*.

FIG. 126.—OSSIFICATION OF THE HUMERUS.


UNITES WITH THE SHAFT AT THE TWENTIETH YEAR.
THE UPPER EPIPHYSIS IS FORMED BY THE UNION OF THE NUCLEUS FOR THE HEAD, GREATER TUBEROSITY, AND THAT FOR THE LESSER TUBEROSITY. THESE FORM A COMMON EPIPHYSIS BEFORE UNITING WITH THE SHAFT
SHAFT BEGINS TO OSSIFY IN THE EIGHTH WEEK OF INTRA-UTERINE LIFE
NUCLEUS FOR THE INTERNAL CONDYLE APPEARS AT FIFTH; FUSES AT THE EIGHTEENTH YEAR
NUCLEUS FOR TROCHLEA APPEARS AT THE TENTH YEAR
NUCLEUS FOR EXTERNAL CONDYLE APPEARS AT FOURTEENTH YEAR
NUCLEUS FOR CAPITELLUM APPEARS IN THE THIRD YEAR
THE CENTRES FOR THE RADIAL CONDYLE. TROCHLEA, AND CAPITELLUM UNITE TOGETHER AND FORM AN EPIPHYSIS WHICH FUSES WITH THE SHAFT AT THE SEVENTEENTH YEAR

The **posterior surface** lies between the ulnar and radial borders. It is obliquely divided by the **musculo-spiral groove.** The surface above the groove serves for the origin of the *external* head; the part below for the *internal head* of the *triceps*.

The **lower extremity** of the humerus is flattened, and presents from the ulnar to the radial side the following parts:—a prominent process, the **ulnar** (internal) **condyle**, from which the *pronator radii teres* arises, and to the lower part of which the internal lateral ligament is attached. From this ligament the *flexor carpi radialis*, *palmaris longus*, *flexor sublimis digitorum*, and *flexor carpi ulnaris* muscles arise. Posteriorly the condyle forms with the trochlea a groove traversed by the ulnar nerve. External to the condyle there is the inferior articular surface, subdivided by a low ridge into the **trochlea** and the **capitellum.** The trochlea is, in shape, like the section of a pulley wheel; the ulnar extends much lower than the radial edge; the articular surface is sharply indicated anteriorly and posteriorly. The trochlea fits into the greater sigmoid cavity of the ulna. Above the trochlea on the anterior surface is the rounded **coronoid fossa,** which receives the coronoid process of the ulna when the forearm is flexed. On the posterior aspect there is the **olecranon fossa,** for the reception of the anterior edge of the olecranon in extension of the forearm. These fossae in most humeri are separated by a thin translucent disc of bone, sometimes merely by fibrous tissue, so that in macerated bones a perforation, the **supratrochlear** foramen, exists. The radial head or capitellum is received by the depression on the summit of the radius; it is limited to the anterior and lower surface of the humerus. Above, it terminates in a shallow fossa, which receives the edge of the radius in flexion. The ridge between the trochlea and the capitellum corresponds to the interval between the ulna and radius; the shallow groove on the outer side of the ridge receives the inner margin of the head of the radius. External to the capitellum is the **external** or **radial condyle.** It is less prominent than the ulnar condyle, and gives attachment to the external lateral ligament of the elbow, and to a tendon from which five extensor muscles arise—viz. *extensores carpi radialis brevior*, *digitorum communis*, *minimi digiti*, *carpi ulnaris*, and the *supinator brevis.* On the posterior aspect this condyle extends to the edge of the trochlea, and gives origin to the *anconeus.*

Muscles.—The humerus affords attachment for the following **muscles** :—

Supra-spinatus.
Infra-spinatus.
Teres major.
Teres minor.
Subscapularis.
Deltoid.
Pectoralis major.
Coraco-brachialis.
Latissimus dorsi.
Biceps (occasionally).
Brachialis anticus.
Triceps.
Pronator radii teres.
Flexor carpi radialis.
Palmaris longus.
Flexor sublimis digitorum.
Flexor carpi ulnaris.
Supinator longus.
Extensor carpi radialis longior.
Extensor carpi radialis brevior.
Extensor digitorum communis.
Extensor minimi digiti.
Extensor carpi ulnaris.
Supinator brevis.
Anconeus.

Ligaments.—To the upper extremity of the humerus the following ligaments are attached:—

Capsular.
Coraco-humeral.
Gleno-humeral.
Transverse humeral.

To the lower extremity:—

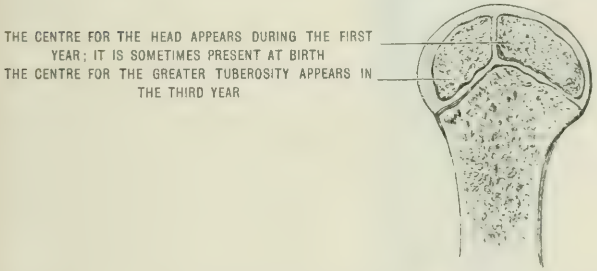
Internal lateral ligament
External lateral ligament
Anterior ligament
Posterior ligament
} of the elbow-joint.

Arteries.—The blood-supply of the humerus is derived from the suprascapular, and the anterior and posterior circumflex arteries. Branches from these arteries enter the foramina which cluster around the circumference of the head and tuberosities. At the top of the bicipital groove there is a large nutrient foramen, which transmits a branch from the anterior circumflex artery. The nutrient artery of the shaft is derived from a muscular branch of the brachial; it enters the bone near the middle of the inner border immediately below the insertion of the coraco-brachialis, and is directed to the distal end. The lower extremity is nourished by numerous twigs derived from the anastomotic, the superior and inferior profunda, and the recurrent branches of the radial, ulnar, and interosseous arteries.

Ossification.—The humerus ossifies from one primary and six secondary nuclei. The centre for the shaft appears about the eighth week of intra-uterine life, and extends very rapidly. At birth the bone presents two cartilaginous extremities, which ossify in the following manner:—A nucleus for the head appears early in the first year; it is not unfrequently present at birth (Spencer). The nucleus for the greater tuberosity appears in the third year. In the fifth year a centre may be deposited for the lesser tuberosity, but this is not constant. The three nuclei coalesce to form a disc of bone, which unites with the shaft about the twentieth year.

The inferior extremity ossifies from four centres: the centre for the capitellum appears in the third year, and those for the inner (ulnar) condyle, the trochlea, and external (radial) condyle at the fifth, tenth, and fourteenth years respectively. The nuclei for the capitellum, trochlea, and radial condyle coalesce before uniting with the shaft, which they do in the seventeenth year. The ulnar condyle joins the shaft somewhat later.

Fig. 127.—The Head of the Humerus at the Sixth Year. (In section.)


THE CENTRE FOR THE HEAD APPEARS DURING THE FIRST YEAR; IT IS SOMETIMES PRESENT AT BIRTH
THE CENTRE FOR THE GREATER TUBEROSITY APPEARS IN THE THIRD YEAR

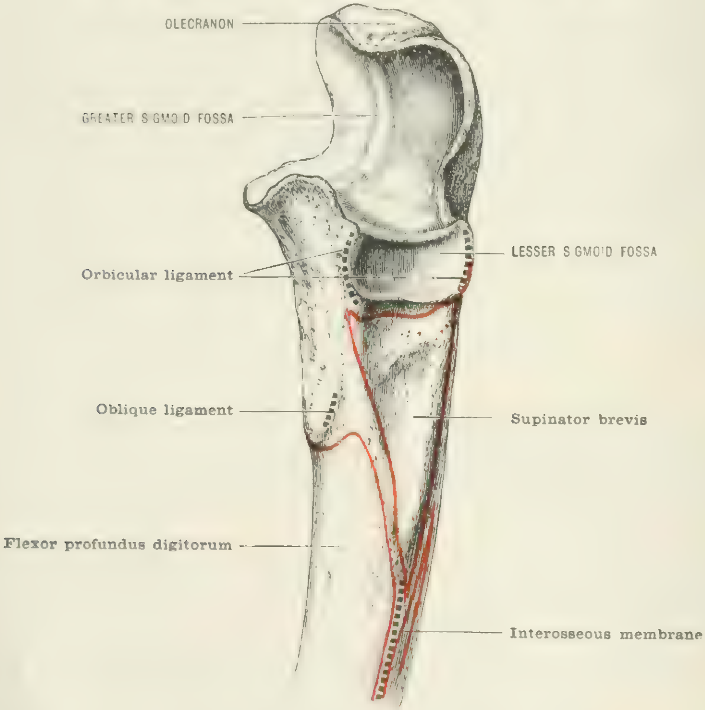
A study of the upper end of the humeral shaft before its union with the epiphysis is of interest in relation to what is known as the neck of the humerus. The term neck is applied to three parts of this bone. The *anatomical* neck is the constriction to which the capsular ligament is attached. This is accurately indicated by the constriction which lies internal to the tuberosities; the upper extremity of the humeral shaft before its union with the epiphysis terminates in a low three-sided pyramid, the surfaces of which are separated from one another by ridges. The inner of these three surfaces underlies the head of the bone, and the two outer surfaces underlie the tuberosities. The axis of the inner, isolated portion forms with the shaft an angle of 130°; it constitutes the morphological neck of the humerus, and is of the same nature as the neck of the femur. The surgical neck is an indefinite area below the tuberosities where the bone is liable to fracture.

THE ULNA

The ulna is the inner bone of the forearm: it lies parallel with, but is longer than, the radius. The upper extremity is the thickest and strongest part of the ulna, and is of irregular shape. The superior articular surface is called the **greater sigmoid cavity,** and receives the trochlea of the humerus: it is transversely constricted near its middle. The prominence above the constriction is termed the **olecranon,** the part below the **coronoid process.**

The **olecranon process** is the highest part of the ulna; into its upper surface the triceps is inserted, and the anterior margin of this surface affords attachment to the posterior ligament of the elbow. The anterior surface of the olecranon is articular, and forms the upper and back part of the greater sigmoid cavity, and its margins give attachment to ligaments. The posterior surface of this process is triangular, and separated from the skin merely by a bursa. On the inner side there is a tubercle for the origin of the *flexor carpi ulnaris;* and below this a fasciculus of the internal lateral ligament of the elbow is inserted. The outer side gives attachment to part of the anconeus.

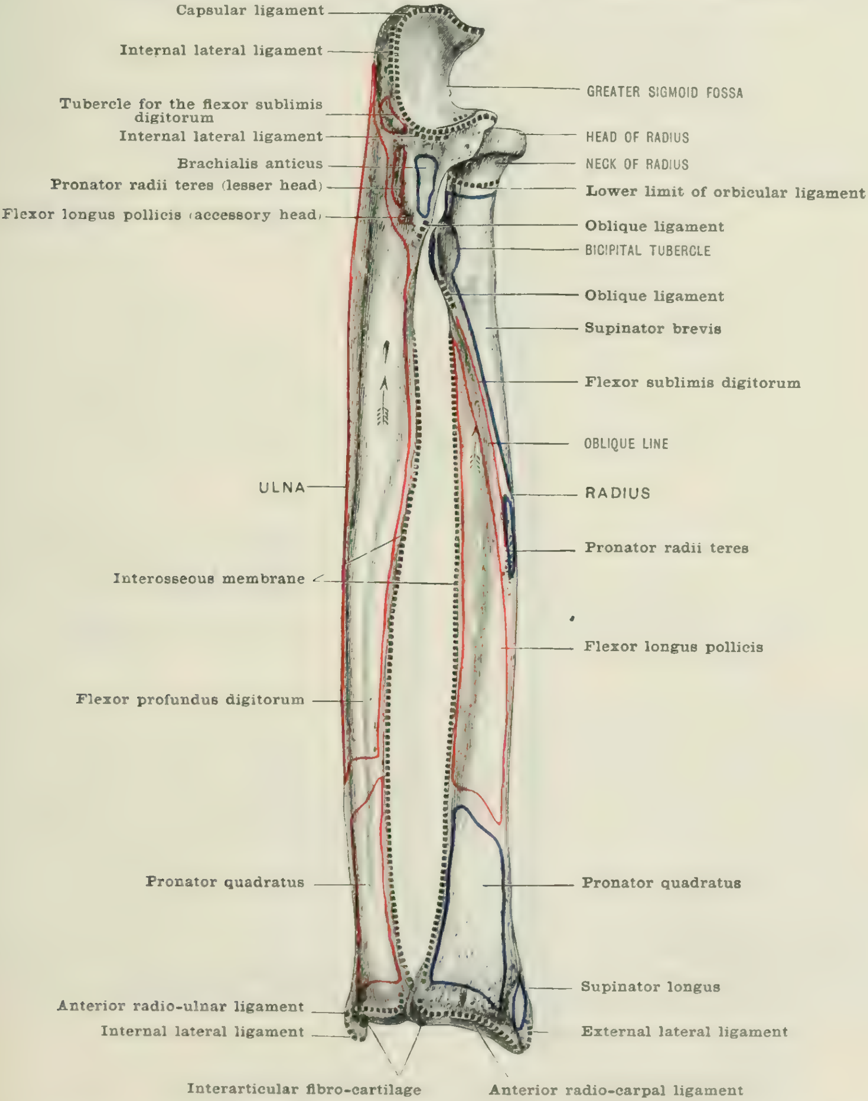
FIG. 128.—UPPER END OF LEFT ULNA. (Outer view.)



The **coronoid process** forms the lower lip of the greater sigmoid cavity: its upper surface is articular and forms nearly a right angle with the olecranon portion. The anterior edge of the coronoid process is sometimes called the apex. The inferior aspect is rough for the insertion of the *brachialis anticus* muscle, and the lower outer angle has a tubercle to which the oblique ligament is attached. The inner edge has a smooth tubercle from which the *flexor sublimis digitorum* arises; the ridge of bone immediately below this tubercle gives origin to the lesser head of the *pronator radii teres,* and below this again the rounded accessory bundle of the *flexor longus pollicis* arises.

A triangular depressed surface, posterior to the *sublimis* tubercle, gives origin to the upper fibres of the *flexor profundus digitorum*. To the outer side of the rough surface for the *brachialis anticus* is a triangular space, the base of which is represented by the **lesser sigmoid cavity,** which receives the lateral articular surface of the head of the radius; the anterior and posterior margins of this cavity afford attachment to the orbicular ligament. The rest of the triangle is depressed, and gives origin to the *supinator brevis.*

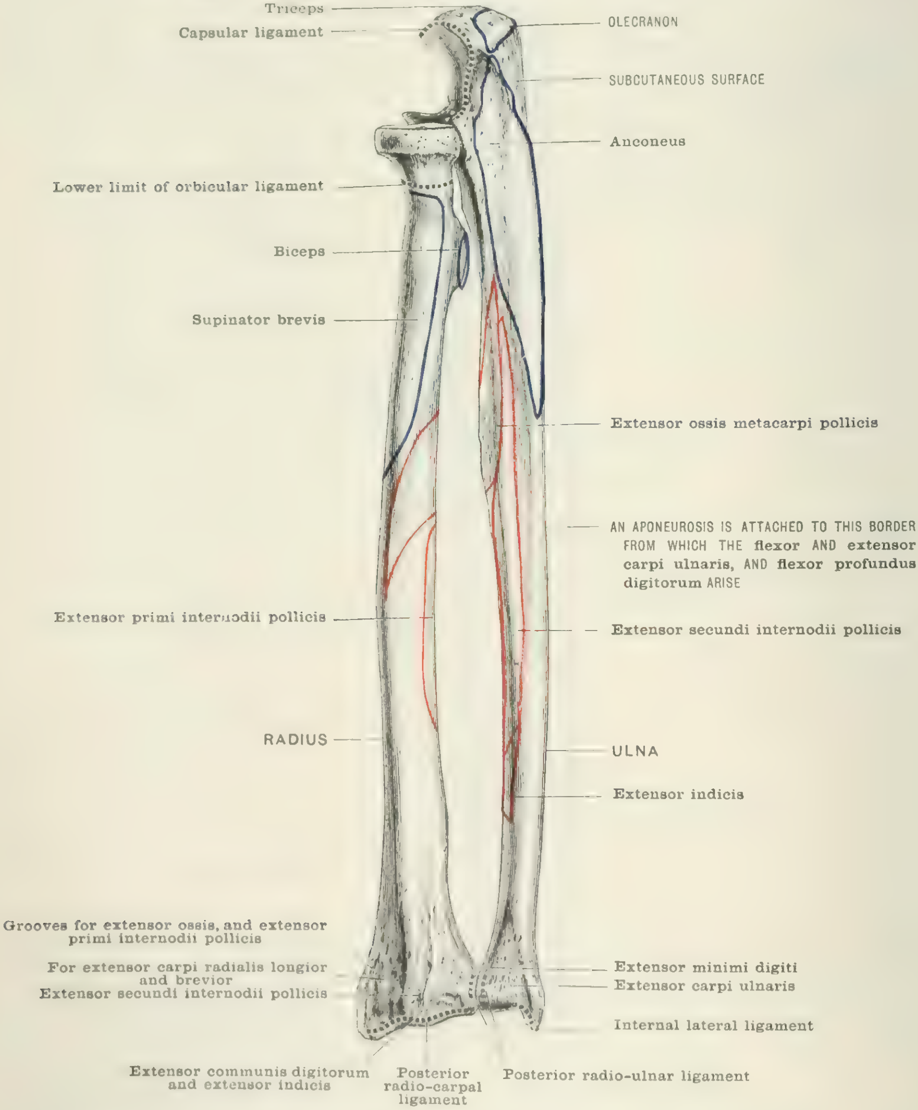
Fig. 129.—The Left Ulna and Radius. (Antero-internal view.)


Capsular ligament
Internal lateral ligament
Tubercle for the flexor sublimis digitorum
Internal lateral ligament
Brachialis anticus
Pronator radii teres (lesser head)
Flexor longus pollicis (accessory head)
GREATER SIGMOID FOSSA
HEAD OF RADIUS
NECK OF RADIUS
Lower limit of orbicular ligament
Oblique ligament
BICIPITAL TUBERCLE
Oblique ligament
Supinator brevis
Flexor sublimis digitorum
OBLIQUE LINE
ULNA
RADIUS
Pronator radii teres
Interosseous membrane
Flexor longus pollicis
Flexor profundus digitorum
Pronator quadratus
Pronator quadratus
Supinator longus
Anterior radio-ulnar ligament
Internal lateral ligament
External lateral ligament
Interarticular fibro-cartilage
Anterior radio-carpal ligament

The **shaft** throughout the greater part of its extent is prismatic, but tapers towards the lower extremity, becoming thin and rounded in its lower third. It has three borders and three surfaces.

Of the three **borders,** the **outer** (or **interosseous**) is the most marked: it commences at the apex of the triangle from which the supinator brevis arises, becomes very prominent in the middle of the bone, but is indefinite near its termination; the interosseous membrane is attached to it. The **anterior** border is directly continuous with the inner edge of the rough surface for the brachialis anticus, and terminates inferiorly in front of the **styloid process**; throughout the greater part of its extent it is rounded, and affords origin to the *flexor profundus digitorum*; in its lower fourth it is rough and prominent for the *pronator quadratus*. The **posterior border** extends from the tubercle, near the tip of the olecranon, to the back part of the styloid process. The upper three-fourths gives attachment to an aponeurosis, from which the *flexor* and *extensor carpi ulnaris* and the *flexor profundus digitorum* muscles arise.

Fig. 130.—The Left Ulna and Radius. (Postero-external view.)


Triceps
Capsular ligament
OLECRANON
SUBCUTANEOUS SURFACE
Anconeus
Lower limit of orbicular ligament
Biceps
Supinator brevis
Extensor ossis metacarpi pollicis
AN APONEUROSIS IS ATTACHED TO THIS BORDER FROM WHICH THE flexor AND extensor carpi ulnaris, AND flexor profundus digitorum ARISE
Extensor primi internodii pollicis
Extensor secundi internodii pollicis
RADIUS
ULNA
Extensor indicis
Grooves for extensor ossis, and extensor primi internodii pollicis
For extensor carpi radialis longior and brevior
Extensor secundi internodii pollicis
Extensor minimi digiti
Extensor carpi ulnaris
Internal lateral ligament
Extensor communis digitorum and extensor indicis
Posterior radio-carpal ligament
Posterior radio-ulnar ligament

Of the three **surfaces**, the **anterior** lies between the anterior and interosseous borders; it is concave for the greater part of its extent. The upper three-fourths gives origin to the *flexor profundus digitorum*, the lower fourth to the *pronator quadratus*; the upper limit of the surface for the pronator is sometimes indicated by an oblique ridge. The **internal surface** is bounded by the anterior and posterior borders. The upper three-fourths is occupied by the *flexor profundus digitorum*; the remainder is subcutaneous. The **posterior surface** lies between the interosseous and posterior borders. Its upper fourth is marked off by an **oblique ridge** running from the lesser sigmoid cavity to the posterior border. The surface above the line receives the insertion of the *anconeus;* from the line itself a few fibres of *supinator brevis* arise. The surface below the oblique line is subdivided by a vertical ridge; the portion lying between this ridge and the posterior border is in relation with the *extensor carpi ulnaris.* Between this line and the interosseous border the following muscles arise in order from above downwards: *extensor ossis metacarpi pollicis,* the *extensor secundi internodii pollicis,* and the *extensor indicis.*

The **lower extremity** of the ulna is of small size and consists of two parts, a **head** and **styloid process,** separated from each other, on the under surface, by a groove into which an interarticular cartilage is inserted. That part of the head adjacent to the groove is semilunar in shape and plays upon the interarticular cartilage which excludes it from the wrist-joint. The margin of the head is also semilunar, and is received into the sigmoid cavity of the radius. The **styloid process** projects from the inner and back part of the bone, and appears as a continuation of the posterior border. To its extremity the internal lateral ligament is attached, and its posterior surface is grooved for the passage of the tendon of the *extensor carpi ulnaris.*

Muscles.—The following are attached to the ulna:—

Triceps.
Anconeus.
Brachialis anticus.
Pronator quadratus.
Flexor sublimis digitorum.
Flexor profundus digitorum.
Flexor longus pollicis.
Flexor carpi ulnaris.
Extensor ossis metacarpi pollicis.
Extensor secundi internodii pollicis.
Extensor indicis.
Pronator radii teres.
Supinator brevis.
Extensor carpi ulnaris.

Ligaments:—

Internal lateral of elbow.
Anterior of elbow.
Posterior of elbow.
Orbicular.
Oblique.
Interosseous membrane.
Anterior radio-ulnar.
Posterior radio-ulnar.
Internal lateral of wrist-joint.
Interarticular fibro-cartilage.

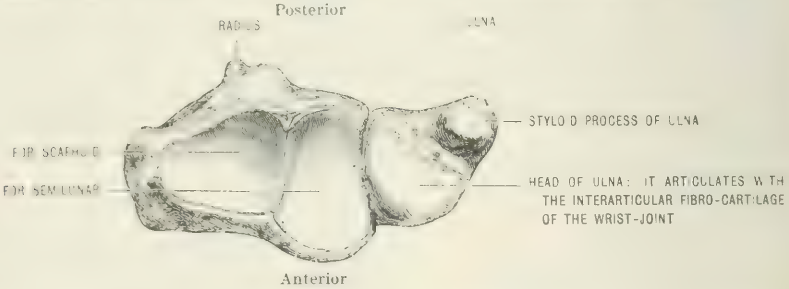
Blood-supply.—The nutrient vessel enters the shaft near the middle of the anterior surface; it is derived from the anterior interosseous trunk, and is directed towards the proximal end. The upper extremity receives branches from the anterior and posterior ulnar recurrent and from the interosseous recurrent. The lower end receives twigs from the anterior and posterior interosseous arteries.

Ossification.—The ulna is ossified from three centres. The primary nucleus appears near the middle of the shaft in the eighth week of embryonic life. At birth the greater portion of the olecranon process is cartilaginous. During the fourth year a nucleus appears for the distal epiphysis. The cartilaginous olecranon is mainly ossified from the shaft, and in the course of the tenth year a scale-like epiphysis appears at its summit. This unites during the sixteenth year. The distal epiphysis consolidates about the eighteenth year.

THE RADIUS

The radius is shorter than the ulna and lies parallel with it. The upper end, or **head**, is surmounted by a circular disc, of which the superior surface is depressed for the reception of the capitellum of the humerus, especially in flexion of the forearm. The margin of the head is also articular; it is deeper on the ulnar aspect, where it is received by the lesser sigmoid cavity of the ulna; the rest of the circumference is embraced by the orbicular ligament. Below the cartilage-covered surface of the bone there is a constricted portion, or **neck**, which is in relation by its outer side with the *supinator brevis.*

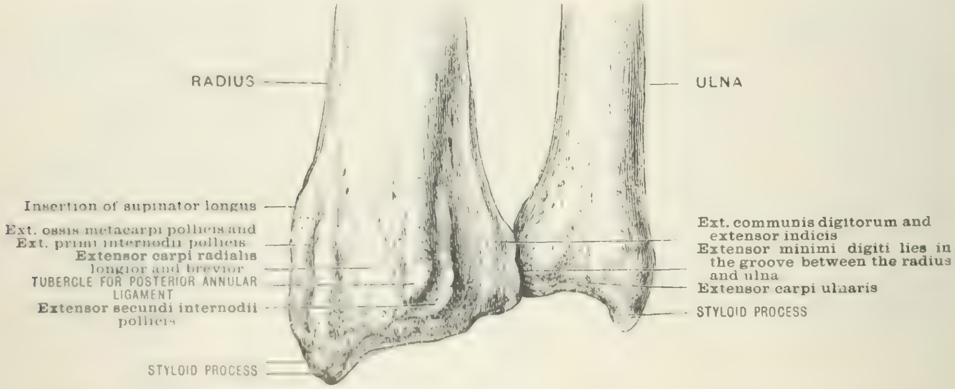
FIG. 131.—ARTICULAR FACETS ON THE LOWER END OF LEFT RADIUS AND ULNA.


Posterior
RADIUS
ULNA
STYLOID PROCESS OF ULNA
FOR SCAPHOID
FOR SEMILUNAR
HEAD OF ULNA: IT ARTICULATES WITH THE INTERARTICULAR FIBRO-CARTILAGE OF THE WRIST-JOINT
Anterior

Beneath the neck, on the antero-internal aspect of the bone, there is an oval eminence, the **bicipital tuberosity,** divided longitudinally into a rough posterior portion for the *biceps tendon*, and a smooth anterior surface in relation with the bursa which is situated between the tendon and the tuberosity.

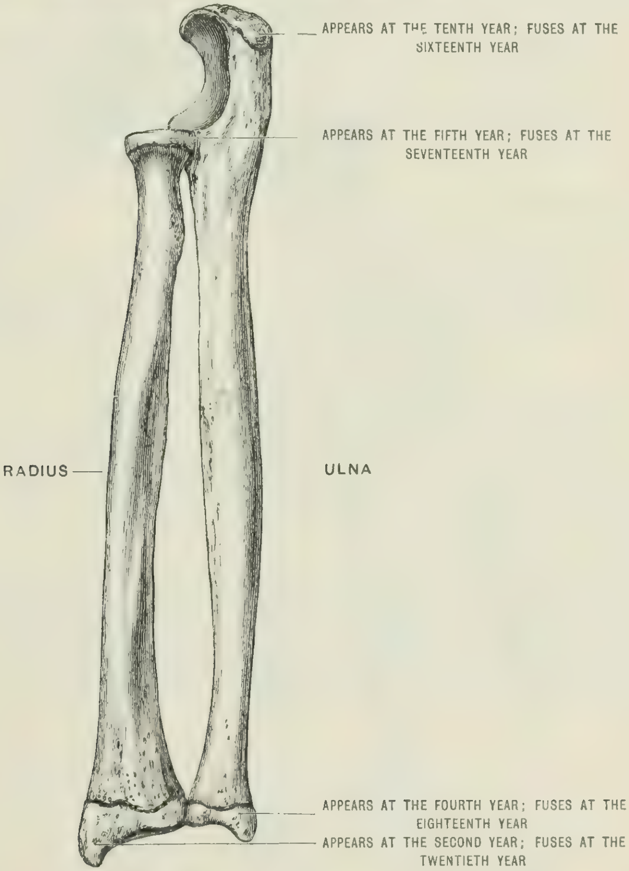
The radius has three borders and three surfaces. Of the three **borders,** the **interosseous** is the best marked. Commencing at the posterior edge of the bicipital tuberosity, it extends as a sharp ridge until it approaches the distal extremity of the bone; it then divides to become continuous with the anterior and posterior margins of the sigmoid cavity. It affords attachment to the interosseous membrane. The **anterior border** starts from the bicipital tuberosity, crosses obliquely to the outer side of the bone, and descends to the anterior border of the **styloid process.** The upper third of this border is called the **oblique line,** and limits the insertion of the *supinator brevis* and the origin of the *flexor longus pollicis,*

FIG. 132.—POSTERIOR VIEW OF THE LOWER END OF THE RADIUS AND ULNA.


RADIUS
ULNA
Insertion of supinator longus
Ext. ossis metacarpi pollicis and Ext. primi internodii pollicis
Extensor carpi radialis longior and brevior
TUBERCLE FOR POSTERIOR ANNULAR LIGAMENT
Extensor secundi internodii pollicis
STYLOID PROCESS
Ext. communis digitorum and extensor indicis
Extensor minimi digiti lies in the groove between the radius and ulna
Extensor carpi ulnaris
STYLOID PROCESS

and affords attachment to the *flexor sublimis digitorum*. The **posterior border** begins at the back of the tuberosity and extends to the middle tubercle on the posterior aspect of the lower extremity. The **anterior surface** is bounded by the anterior and interosseous borders. The upper two-thirds is occupied by the *flexor longus pollicis*, and a little less than the lower third by the *pronator quadratus*. The **external surface** lies between the anterior and posterior borders. The upper third affords insertion to the *supinator brevis;* at its centre there is a rough, low, vertical ridge for the *pronator radii teres;* below this, the bone is smooth and overlapped by the tendons of the *extensores carpi radialis longior* and *brevior*, and crossed by the *extensor ossis metacarpi pollicis* and *extensor primi internodii pollicis*. The **posterior** **surface** lies between the interosseous and posterior borders. The upper third gives origin to the *extensor ossis metacarpi* and the *extensor primi internodii pollicis*, and the lower third is covered by tendons.

Fig. 133.—Ossification of the Radius and Ulna.


APPEARS AT THE TENTH YEAR; FUSES AT THE SIXTEENTH YEAR
APPEARS AT THE FIFTH YEAR; FUSES AT THE SEVENTEENTH YEAR
RADIUS
ULNA
APPEARS AT THE FOURTH YEAR; FUSES AT THE EIGHTEENTH YEAR
APPEARS AT THE SECOND YEAR; FUSES AT THE TWENTIETH YEAR

The **lower extremity** of the radius is quadrilateral; its carpal surface is articular and divided by a ridge into an inner quadrilateral portion, concave for articulation with the semilunar bone; and an outer triangular portion, extending on to the styloid process: this is concave to receive the superior surface of the scaphoid bone. The inner side of the lower end presents the **sigmoid cavity** for the reception of the rounded margin of the head of the ulna. The anterior surface is a raised ridge to which the anterior ligament of the wrist-joint is attached. The outer surface is represented by the **styloid process,** to the base of which the *supinator longus* is inserted; and the tip of the process serves for the attachment of the external lateral ligament of the wrist. It is also marked by a shallow furrow for the tendons of the *extensor ossis metacarpi* and *extensor primi internodii pollicis*. The posterior surface is convex, and marked by three prominent ridges separating three furrows. The posterior annular ligament is attached to these ridges, to the styloid process, and to the inner margin, thus forming with the bone a series of tunnels. The outermost is broad, shallow, and frequently subdivided by a low ridge. The outer subdivision is for the *extensor carpi radialis longior*, the inner for the *extensor carpi radialis brevior*. The middle groove is narrow and deep for the tendon of the *extensor secundi internodii pollicis*. The innermost is shallow and transmits the *extensor indicis* and the *extensor communis digitorum* which overlies the *indicis*, the posterior branch of the anterior interosseous artery and the posterior interosseous nerve. When the radius and ulna are articulated, an additional groove is formed for the *extensor minimi digiti*.

Muscles.—The following muscles are attached to the radius:—

Biceps.
Supinator brevis.
Supinator longus.
Pronator radii teres.
Pronator quadratus.
Extensor ossis metacarpi pollicis.
Extensor primi internodii pollicis.
Flexor longus pollicis.
Flexor sublimis digitorum.

Ligaments:—

Oblique ligament.
Interosseous membrane.
Anterior radio-ulnar.
Posterior radio-ulnar.
Posterior annular.
External lateral of wrist.
Interarticular fibro-cartilage of wrist.
Anterior radio-carpal.
Posterior radio-carpal.

Blood-supply.—The nutrient artery is derived from the anterior interosseous trunk; it enters the shaft near the middle of the anterior surface, and runs towards the proximal end of the bone. The head of the bone is supplied by the radial recurrent and interosseous recurrent arteries. The lower end is supplied by the anterior and posterior interosseous arteries and numerous twigs from the carpal arches.

Ossification.—The radius is ossified by one primary and two secondary centres. The shaft begins to ossify at the eighth week of embryonic life. The nucleus for the lower end appears in the second year, whilst that for the upper end is deposited in the fifth year. The head ankyloses with the shaft at the seventeenth year, but consolidation is delayed at the lower end until the twentieth year.

THE HAND

The skeleton of the hand consists of three parts—the **carpus**, **metacarpus**, and **phalanges**.

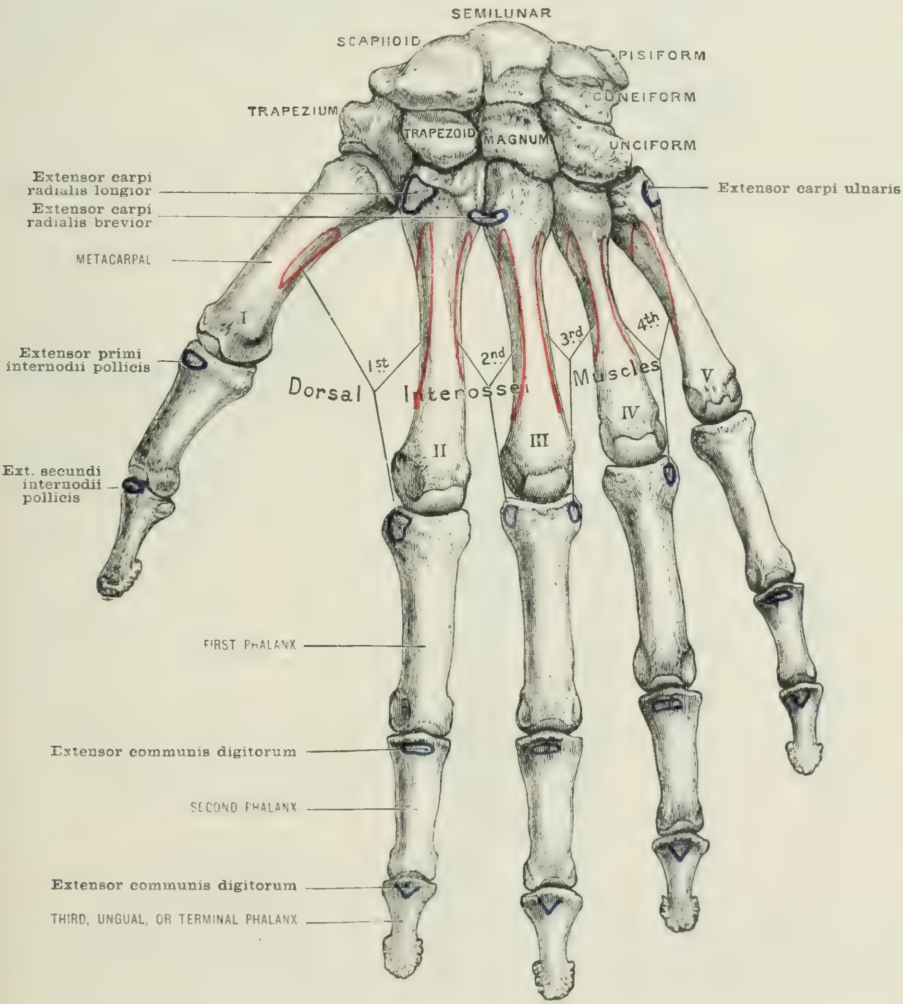
THE CARPUS

The **carpus** contains eight bones, arranged in two rows, four bones in each row. Enumerated from the radial to the ulnar side, the bones of the proximal row are, the **scaphoid**, **semilunar**, **cuneiform**, and **pisiform**; those of the distal row, the **trapezium**, **trapezoid**, **magnum**, and **unciform**. The anterior and posterior surfaces of all the carpal bones, except the pisiform and cuneiform, are non-articular; the anterior surfaces of the bones of the upper row are larger than the posterior, but in the lower row this arrangement is reversed.

The Scaphoid

This is the largest bone of the proximal row. Its **superior** surface is somewhat triangular and convex for articulation with the lower end and **styloid** process of the radius. Its **inferior surface** has two facets: a large one for the trapezium, and a small one for the trapezoid. The **dorsal surface** is occupied by a long, deep groove for ligaments. The **palmar surface** is rough and concave above; below, it has a prominent tuberosity for the attachment of the anterior annular ligament and the *abductor pollicis* muscle. The **outer** (radial) **surface** is rough for ligaments. The **inner** (**ulnar**) **surface** is occupied by two articular facets, of which the upper one is crescentic in shape for the semilunar bone, whilst the lower is deeply concave for the reception of the head of the magnum.

Fig. 134.—The Left Hand. (Dorsal surface.)


SEMILUNAR
SCAPHOID
PISIFORM
CUNEIFORM
TRAPEZIUM
TRAPEZOID
MAGNUM
UNCIFORM
Extensor carpi radialis longior
Extensor carpi radialis brevior
Extensor carpi ulnaris
METACARPAL
I
1st
2nd
3rd
4th
Dorsal Interossei Muscles
V
IV
II
III
Extensor primi internodii pollicis
Ext. secundi internodii pollicis
FIRST PHALANX
Extensor communis digitorum
SECOND PHALANX
Extensor communis digitorum
THIRD, UNGUAL, OR TERMINAL PHALANX

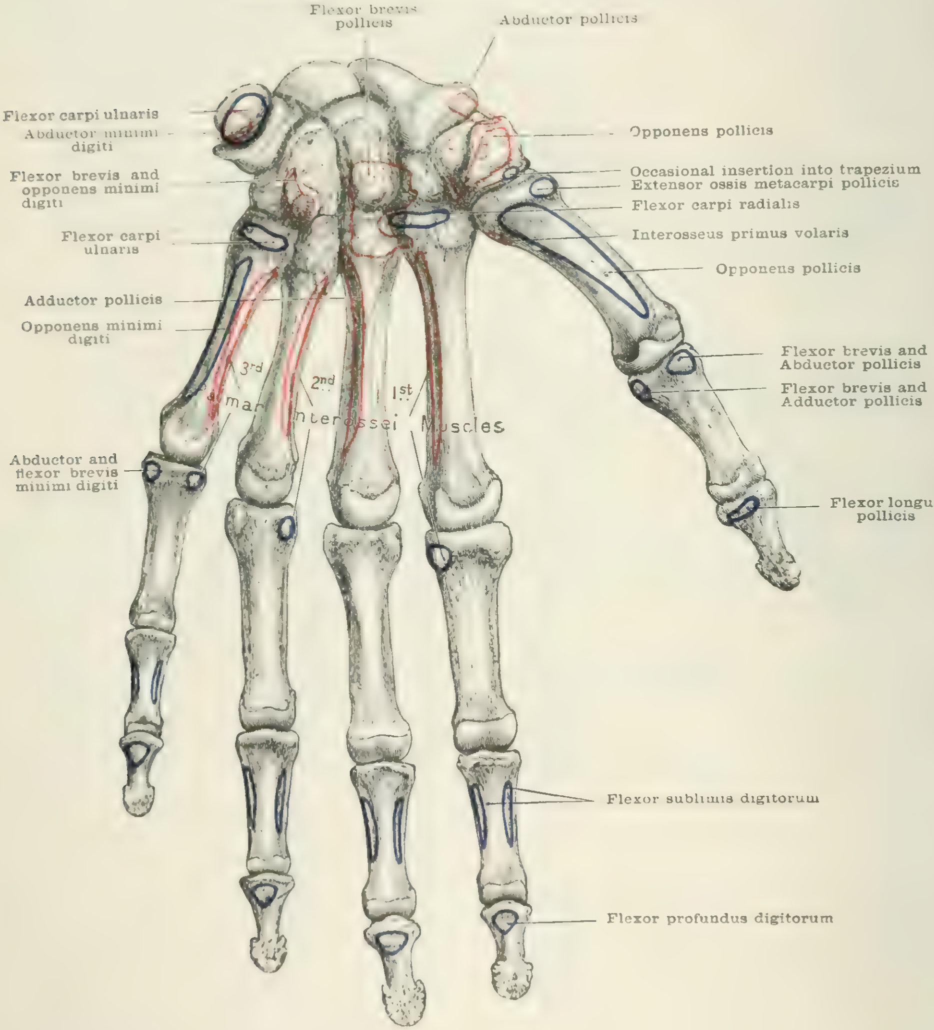
Articulations.—With radius, trapezium, trapezoid, magnum, and semilunar.

The Semilunar

The **semilunar** has a convex **superior surface** for articulation with the lower end of the radius and the fibro-cartilage of the wrist. Its **inferior surface** is deeply concave for the head of the magnum. The ulnar ridge of the inferior articular surface is faceted for the unciform. The **outer** (radial) **surface** has a narrow semilunar facet for the scaphoid, whilst the **inner** (ulnar) **aspect** of the bone presents a quadrilateral facet for the base of the cuneiform. The **palmar** and **dorsal surfaces** are rough and non-articular.

Articulations.—With the radius, scaphoid, cuneiform, magnum, and unciform.

FIG. 135.—THE LEFT HAND. (Palmar surface.)


Flexor brevis pollicis
Abductor pollicis
Flexor carpi ulnaris
Abductor minimi digiti
Opponens pollicis
Occasional insertion into trapezium
Extensor ossis metacarpi pollicis
Flexor carpi radialis
Flexor brevis and opponens minimi digiti
Interosseus primus volaris
Flexor carpi ulnaris
Opponens pollicis
Adductor pollicis
Opponens minimi digiti
3rd
2nd
1st
Palmar Interossei Muscles
Flexor brevis and Abductor pollicis
Flexor brevis and Adductor pollicis
Abductor and flexor brevis minimi digiti
Flexor longus pollicis
Flexor sublimis digitorum
Flexor profundus digitorum

THE CUNEIFORM

The **cuneiform** (or pyramidal bone) rests by its base on the ulnar side of the semilunar; its **apex** is directed downwards and to the ulnar side, and serves for the attachment of the internal lateral ligament of the wrist. The base presents a facet for the semilunar. The **inferior surface** has a sinuous articular surface for the unciform bone. The **superior surface** has a convex smooth portion, where it plays upon the interarticular cartilage which intervenes between it and the lower end of the ulna; the remainder of this surface is rough for ligaments. The **palmar**

surface has a conspicuous facet for the pisiform bone near the inner extremity, and the **dorsal surface** is rough for ligaments.

Articulations.—Pisiform, semilunar, and unciform.

Fig. 136.—The Left Scaphoid.

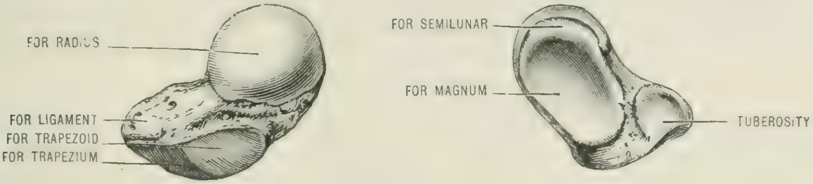
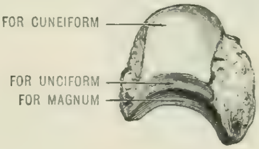

FOR RADIUS
FOR LIGAMENT
FOR TRAPEZOID
FOR TRAPEZIUM
FOR SEMILUNAR
FOR MAGNUM
TUBEROSITY

Fig. 137.—The Left Semilunar.


FOR CUNEIFORM
FOR UNCIFORM
FOR MAGNUM

The Pisiform

The **pisiform** resembles closely a split pea. Its **dorsal** aspect, corresponding to the cut surface of the pea, articulates with the facet on the palmar surface of the cuneiform. The rest of this bone is rough for the anterior annular ligament and the tendon of the *flexor carpi ulnaris.*

Fig. 138.—The Left Cuneiform.

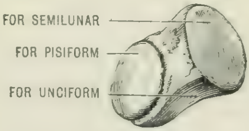
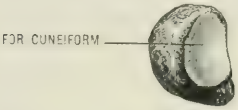

FOR SEMILUNAR
FOR PISIFORM
FOR UNCIFORM

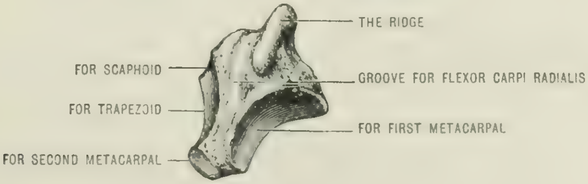
Fig. 139.—The Left Pisiform.


FOR CUNEIFORM

The Trapezium

The **trapezium** is the first bone of the distal row; it is very irregular in shape. The **inferior surface** is saddle-shaped, and articulates with the base of the first metacarpal bone. The **superior surface** has a facet for the scaphoid. The **inner (ulnar) surface** has two facets; the lower and smaller is for the base of the second

Fig. 140.—The Left Trapezium.


THE RIDGE
FOR SCAPHOID
GROOVE FOR FLEXOR CARPI RADIALIS
FOR TRAPEZOID
FOR FIRST METACARPAL
FOR SECOND METACARPAL

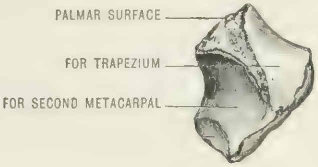
metacarpal, the upper and larger for the trapezoid. The **radial** and **dorsal surfaces** are rough for ligaments. The **palmar surface** presents a prominent ridge, which has to its ulnar side a deep groove which transmits the tendon of the *flexor carpi radialis.* To the **ridge** of the trapezium the anterior annular ligament is attached. The palmar surface affords attachment to the *abductor, flexor ossis, flexor brevis,* and sometimes a portion of the *extensor ossis metacarpi pollicis.*

Articulations.—With the scaphoid, trapezoid, and the first and second metacarpal bones.

THE TRAPEZOID

The **trapezoid** is also very irregular in shape, and much smaller than the trapezium. It has a broad **dorsal surface**; the narrow **palmar surface** gives origin to a few fibres of the inner head of the *flexor brevis pollicis.* The portion of bone between these surfaces is constricted and mapped out into articular facets; of these, the **inferior** is most conspicuous; it is saddle-shaped for the base of the second metacarpal. The **radial surface** has a facet for the trapezium; the **ulnar surface** is articular for the magnum; and the superior surface has a facet for the scaphoid.

FIG. 141.—THE LEFT TRAPEZOID.

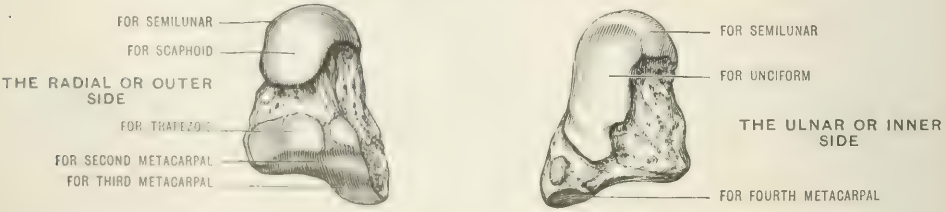


Articulations.—With the trapezium, magnum, scaphoid, second metacarpal.

THE MAGNUM

The **magnum** is the largest carpal bone, and occupies the centre of the wrist. The **superior surface** is globular, and sometimes called the **head.** It is received into the cup formed by the semilunar and scaphoid. The articular surface of the head extends some distance on to the dorsal aspect of the bone. The **inferior surface** has three facets. The middle is the largest for the base of the third metacarpal. The small ulnar facet is for the fourth, and the radial facet is for the second metacarpal. The **outer** (radial) **surface** articulates with the trapezoid, and presents above this small facet a deep groove for an interosseous ligament. The **inner** (ulnar) **surface** of the bone has a long articular surface for the unciform (sometimes the lower part of this surface forms a detached facet), but is rough near its anterior part for ligaments. The **palmar surface** is convex and rough, and affords origin to the inner head of the *flexor brevis pollicis.* The rough **dorsal surface** is broad, and has a deep concavity, which serves to make the head of the bone more prominent, and gives rise to the appearance of a neck.

FIG. 142.—THE LEFT MAGNUM.

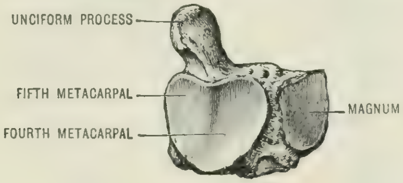


Articulations.—Trapezoid, unciform, semilunar, scaphoid, and second, third, and fourth metacarpals.

THE UNCIFORM

The **unciform** is the most readily recognised of all the carpals, as its **palmar surface** presents a prominent hook-like process; this, the **unciform process,** has its concavity directed towards the radial side, and forms part of the inner boundary of the passage for the flexor tendons; to the apex of the process the anterior annular ligament gains an attachment. It also affords origin to the *flexor brevis minimi* and *opponens minimi digiti* muscles. The **dorsal surface** is rough for ligaments. The **inferior surface** has two facets for the bases of fourth and fifth metacarpals. The **superior surface** forms the apex of a wedge, and is smooth and rounded for articulating with a narrow facet on the ulnar side of the lower surface of the semilunar. The **ulnar surface** is mainly articular for the cuneiform, whilst the **radial surface** is faceted for the magnum.

FIG. 143.—THE LEFT UNCIFORM.



Articulations.—With the cuneiform, semilunar, magnum, and the fourth and fifth metacarpals.

The **central** is an occasional element of the carpus. It is situated on the dorsal aspect of the carpus, between the scaphoid, magnum, and trapezoid. This bone is a normal element of the carpus in many mammals, even in the orang and gibbon. It is represented in the carpus of the human embryo, but in most individuals it undergoes suppression or coalesces with the scaphoid.

Blood-supply.—The arterial twigs to the carpal bones are derived from the anterior and posterior carpal branches of the radial and ulnar arteries. A large branch from the anterior interosseous is also distributed to the carpus, and twigs are furnished to it from the posterior interosseous artery.

Ossification.—At birth the carpal elements are cartilaginous, and the nucleus for each bone appears in the following order:—

Magnum, first year.
Unciform, second year.
Cuneiform, third year.
Semilunar, fourth year.
Trapezium, fifth year.
Scaphoid, sixth year.
Trapezoid, eighth year.
Pisiform, twelfth year.

THE METACARPUS

The **metacarpus** consists of five bones. Each metacarpal bone has a **shaft,** a rounded **distal** end termed the **head,** and a square-shaped proximal extremity named the **base.** The shaft is prismatic; two surfaces of the prism are lateral, and the third dorsal. The **lateral** surfaces afford attachment to the *interosseous* muscles: on the **palmar aspect** of the shaft these surfaces approach each other, and for some distance are only separated by a prominent ridge. The **dorsal surface** is smooth and covered in the recent state by the tendons of the extensor muscles of the fingers. Near the base, this surface is divided by a median ridge; as this ridge passes to the distal end of the shaft, it divides and forms two ridges which terminate in a prominent **tubercle** on each side of the head of the bone. The smooth surface on each side of the median ridge on the dorsal aspect, near the base, is for a *dorsal interosseous* muscle. The **base** is quadrilateral; its palmar and dorsal surfaces are rough for ligaments; the upper end articulates with the carpus, and its lateral aspects have facets for adjacent metacarpals. The **head** has a semilunar articular surface for the base of the first phalanx, and is more extensive on the palmar than the dorsal aspect. On its palmar surface the head is grooved for flexor tendons, each corner of the groove being surmounted by a tubercle. The sides of the head are compressed, and each side is occupied by a well-marked fossa.

The several **metacarpals** present distinctive characters. The First is the most peculiar: it is the shortest, and its shaft resembles that of a phalanx. It has a concave palmar surface, and the dorsal surface lacks the bifurcated ridge. The **base** has a saddle-shaped articular surface for the trapezium, and at its outer (radial) corner presents a tubercle for the insertion of the *extensor ossis metacarpi pollicis*. The **head** of the bone presents on its palmar aspect two shallow grooves for the sesamoids in the *flexor brevis pollicis*.

Fig. 144.—The First (Left) Metacarpal.

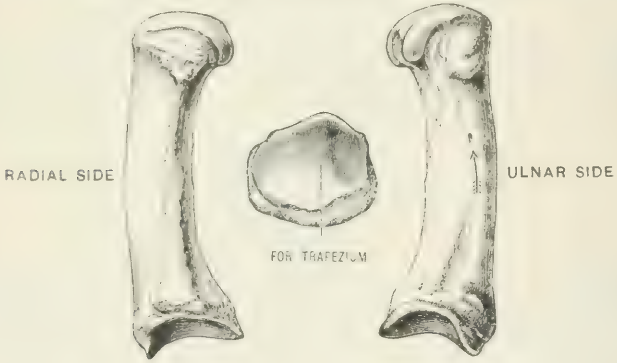
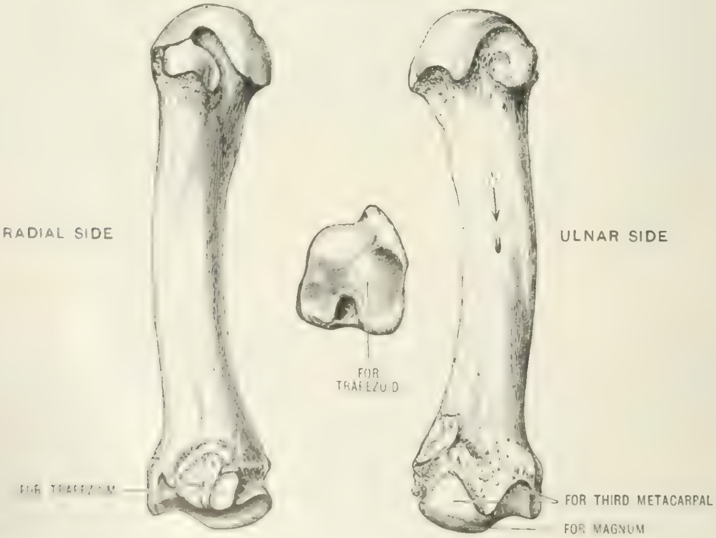


Fig. 145.—The Second (Left) Metacarpal.



Muscles:—

Extensor ossis metacarpi pollicis.
Opponens pollicis.
First dorsal interosseous.
Interosseus primus volaris.

Blood-supply.—The nutrient vessel is derived from the princeps pollicis artery: it enters on the ulnar side, and is directed towards the head of the bone.

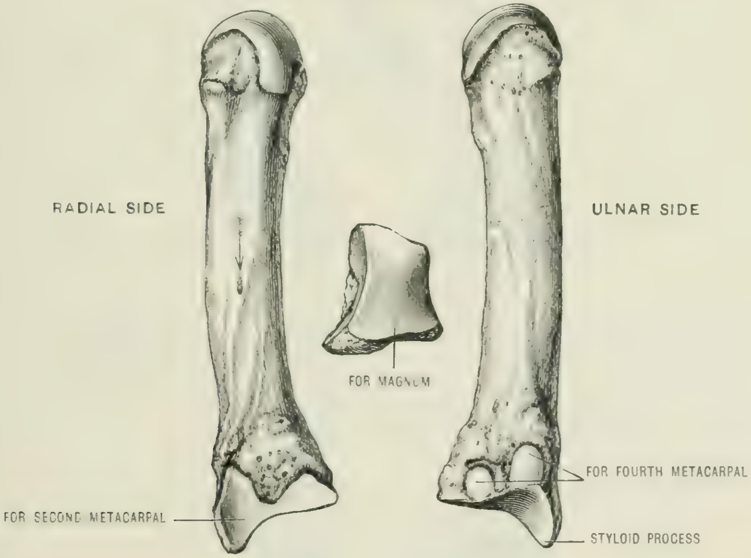
The SECOND METACARPAL is the longest, and is easily recognised by its large deeply cleft **base.**

The **dorsal** surface affords attachment to the tendon of the *extensor carpi radialis longior* and a part of the *extensor carpi radialis brevior;* to the **palmar** surface the tendon of the *flexor carpi radialis* is inserted. The remaining surfaces present four articular facets. The end of the bone is occupied by a deep groove for the trapezoid; the ulnar ridge of this concavity is smooth for the magnum, and is directly continuous with a long narrow facet for the third metacarpal. The radial surface of the base has a small, somewhat quadrangular facet for the trapezium.

Muscles :—

Flexor carpi radialis.	First and second dorsal interosseous.
Extensor carpi radialis longior.	First palmar interosseous.
Extensor carpi radialis brevior.	Flexor brevis pollicis.

FIG. 146.—THE THIRD (LEFT) METACARPAL.



Blood-supply.—The nutrient artery is derived from the first palmar interosseous. It enters on the ulnar side, and is directed towards the proximal end or base of the bone.

The THIRD METACARPAL is easily recognised by the prominent **styloid process** which projects from the radial corner of the dorsal surface of the base. A little below this process the *extensor carpi radialis brevior* finds insertion. The carpal surface of the base is nearly plane for the magnum. The radial surface has a long narrow facet for the second metacarpal. On the ulnar side, two rounded facets are usually seen for the fourth metacarpal. Not unfrequently one of them is absent.

Muscles :—

Extensor carpi radialis brevior.	Second and third dorsal interosseous.
Adductor pollicis.	Flexor carpi radialis.

Blood-supply.—The nutrient artery is derived from the interosseous: it enters, as a rule, on the radial side, and is directed towards the base.

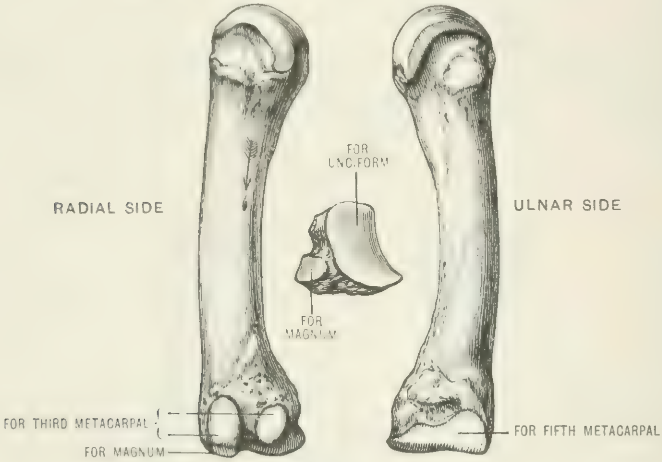
The FOURTH METACARPAL has a very small base. By its carpal surface it articulates with the unciform. The radial surface has two rounded facets for the third metacarpal; there is a small facet for the magnum at the posterior radial corner. The ulnar side has a narrow articular surface for the fifth metacarpal.

Muscles:—

The third dorsal interosseous. The fourth dorsal interosseous.
The second palmar interosseous.

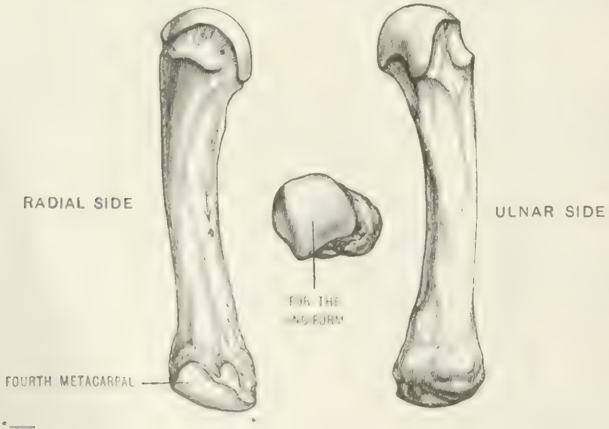
Blood-supply.—The nutrient artery is furnished by the second interosseous; it enters on the radial side of the shaft, and is directed towards the proximal end.

Fig. 147.—The Fourth (Left) Metacarpal.


RADIAL SIDE
FOR UNCIFORM
ULNAR SIDE
FOR MAGNUM
FOR THIRD METACARPAL
FOR MAGNUM
FOR FIFTH METACARPAL

The Fifth Metacarpal is readily distinguished. The carpal facet is convex for the unciform. The ulnar aspect of the base forms a rounded tubercle for the *extensor carpi ulnaris*, whilst the radial side has a semilunar facet for the fourth metacarpal bone. The radial border of the dorsal surface of the shaft often has a prominent lip for the fourth dorsal interosseous muscle.

Fig. 148.—The Fifth (Left) Metacarpal.


RADIAL SIDE
ULNAR SIDE
FOR THE UNCIFORM
FOURTH METACARPAL

Muscles:—

Flexor carpi ulnaris. Fourth dorsal interosseous.
Extensor carpi ulnaris. Third palmar interosseous.
Opponens minimi digiti.

Blood-supply.—The nutrient artery is derived from the third interosseous. It enters the shaft on the radial side, and is directed towards the proximal end.

Ossification.—Each metacarpal is ossified from two centres. The nucleus for the shaft appears about the eighth week of embryonic life. At birth the shafts are well ossified, but each end is capped by a piece of cartilage. In the case of the first metacarpal, a centre for the epiphysis appears at the proximal end in the course of the third year. The bases of the remaining metacarpals are ossified from the shaft, but an epiphysis forms for the head of each bone in the third year. The bones are usually consolidated by the twentieth year.

In many cases the first metacarpal has two epiphyses, one at the base and an additional one at the head; the latter is never so large as in the other metacarpal bones.

The third metacarpal occasionally has an additional nucleus for the prominent styloid process which constitutes such a distinguishing feature of this bone.

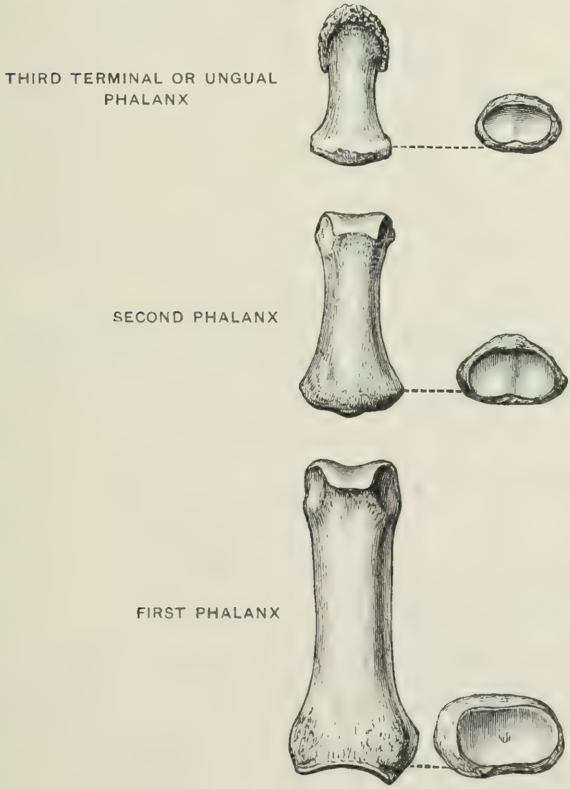
The styloid process sometimes remains distinct, and is then known as the **styloid bone.** Occasionally it fuses with the trapezoid or magnum.

THE PHALANGES

The phalanges are the bones of the fingers. They number in all fourteen: the thumb has two, the other fingers three each.

Each phalanx has a **shaft,** which is broad and slightly concave on the palmar, rounded and smooth on the dorsal aspect. The sides of the palmar surface are raised where they give attachment to the sheaths of the flexor tendons. The base of each phalanx of the first row presents a glenoid fossa which plays upon the convex head of the metacarpal bone. The distal end is surmounted by miniature condyles.

Fig. 149.—The Phalanges of the Third Digit of the Hand. (Dorsal view.)

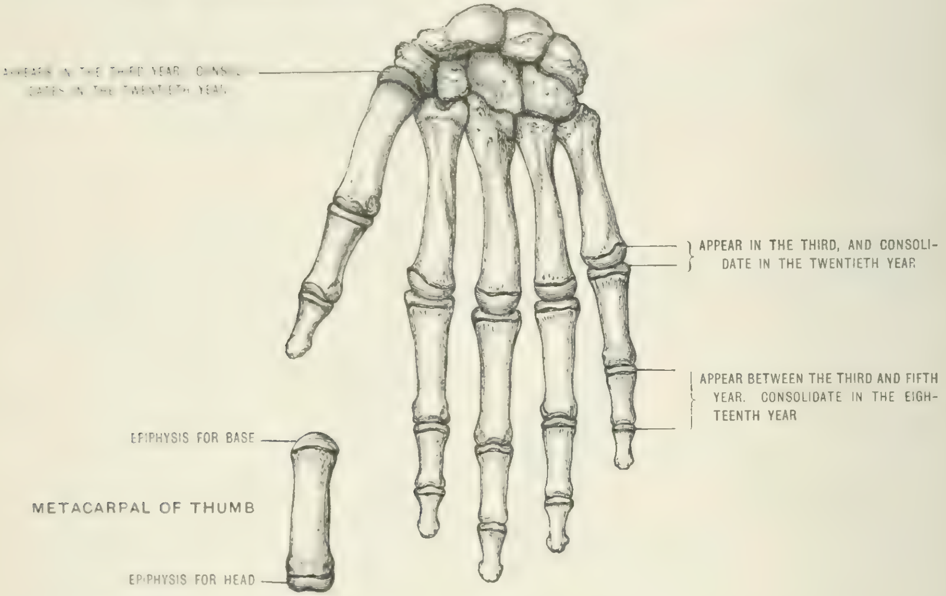


The phalanges of the **second row** are shorter than those of the first row. Their bases present **two shallow pits,** separated by a ridge.

The **terminal, third,** or **ungual** phalanges have an expanded shaft for the support of the nail. The bases are identical in shape with those of the second row.

Ossification.—Each phalanx ossifies from two centres: one for the shaft, which is deposited between the eighth and tenth weeks; and a nucleus for the epiphysis at the proximal end, which appears between the third and fifth years. Consolidation begins at the seventeenth, and is complete by the eighteenth year.

Fig. 150. Ossification of the Metacarpals and Phalanges.


APPEARS IN THE THIRD YEAR. CONSOLIDATES IN THE TWENTIETH YEAR.
APPEAR IN THE THIRD, AND CONSOLIDATE IN THE TWENTIETH YEAR
APPEAR BETWEEN THE THIRD AND FIFTH YEAR. CONSOLIDATE IN THE EIGHTEENTH YEAR
EPIPHYSIS FOR BASE
METACARPAL OF THUMB
EPIPHYSIS FOR HEAD

The ossification of the terminal phalanx is peculiar. Like the other phalanges it has a nucleus for the shaft and a secondary nucleus for the epiphysis; but the centre for the shaft appears at the **tip** of the phalanx; whereas in the other phalanges the earthy matter is deposited in the **middle** of the shaft.

THE HIP-BONE

The hip-bone (innominate bone) is of irregular shape, resembling somewhat the blade of a screw propeller. It consists of three parts, which, though separate in early life, are, in the adult, firmly ankylosed. The three parts meet together at the **cotyloid cavity** or **acetabulum.** They are named **ilium, ischium,** and **pubes.**

The ilium is the upper expanded portion; it articulates with the sacrum, and forms the upper two-fifths of the acetabulum. The ischium is the lowest part of the bone; it forms the posterior and inferior two-fifths of the acetabulum, and assists the pubes to form the **obturator foramen.** The pubes forms the anterior fifth of the acetabulum, completes the obturator foramen, and stretches towards the median line to meet with the opposite pubes to form a **symphysis.** Each part requires separate consideration.

The **ilium** has two surfaces: the external surface, or **dorsum**, is convex in its general contour. It is limited superiorly by the semicircular **crest**, and is crossed by the three **gluteal ridges.** The **superior gluteal ridge** commences at the crest about 5 cm. (2″) from its posterior termination, and passes downwards to the middle of the **greater sciatic** (ilio-sciatic) **notch.** The space included between this ridge and the crest gives origin to the *gluteus maximus*, and at its lower part to a few fibres of the *pyriformis*. The **middle gluteal ridge** extends from the crest 2·5 cm. (1″) behind its anterior extremity, and passes across the dorsum to terminate near the posterior end of the superior gluteal ridge, at the greater sciatic notch. The surface of bone between this ridge and the crest is for the origin of the *gluteus medius*. The **inferior gluteal ridge** begins in the notch separating the anterior iliac spines, and terminates posteriorly in the middle of the greater sciatic notch. The space between the middle and inferior ridges gives origin to the *gluteus minimus*, except a small area adjacent to the anterior superior iliac spine for the *tensor vaginæ femoris*. The bone between the inferior gluteal ridge and the margin of the acetabulum affords attachment to the capsule of the hip-joint. Towards its anterior part there is a rough surface for the *reflected tendon* of the *rectus*.

The internal surface of the ilium consists of an anterior concave portion, termed the **iliac fossa**; it lodges the *iliacus* muscle. The fossa is limited below by the *ilio-pectineal line;* this line receives, at its anterior part, the insertion of the *psoas parvus*. A small portion of the ilium extends below the ilio-pectineal line to meet the ischium. The surface posterior to the fossa is divided into an **auricular surface** for articulation with the lateral aspect of the upper portion of the sacrum, and a superior rough surface—**the tuberosity**—for the posterior sacro-iliac and ilio-lumbar ligaments. The **crest** extends from the anterior superior iliac to the posterior superior iliac spine. It is thickest at its extremities. The prominent edges, or lips, are for the attachment of muscles and fasciæ.

The outer lip affords attachment to the gluteal portion of the fascia lata. The *external oblique* is inserted into the anterior half, and the *latissimus dorsi* arises for about an inch more posteriorly. The anterior two-thirds of the intermediate space gives origin to the *internal oblique*. The inner lip, by its anterior three-fourths, gives attachment to the *transversalis;* behind this is a small surface for the *quadratus lumborum*, and the remainder is occupied by the *erector spinæ*. The extreme inner margin of the lip in the anterior two-thirds serves for the attachment of the iliac fascia.

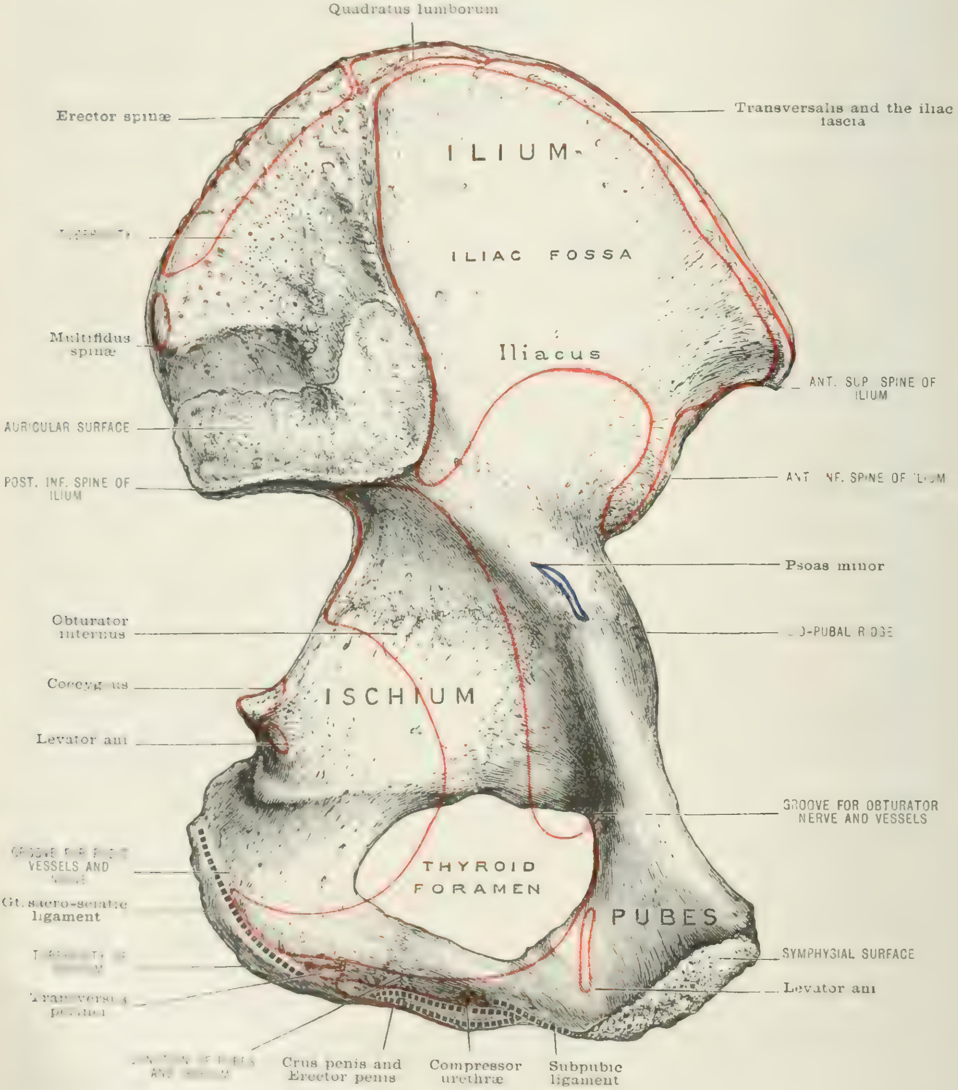
The **anterior border** of the ilium extends from the anterior superior spine to the margin of the acetabulum. The **anterior superior spine** gives attachment to Poupart's ligament, and the *sartorius* which also arises from the upper half of the **superior iliac notch.** This notch is terminated inferiorly by the **anterior inferior spine**; it is smaller, less prominent than the superior, and gives origin to the straight head of the *rectus femoris* and the main limb of the ilio-femoral band of the capsule of the hip-joint. Beneath the inferior iliac spine is the **inferior iliac notch**; it is broad, but shallow, and limited by an eminence, the **ilio-pubal ridge,** which indicates the line of ankylosis of the pubes and the ilium. A few fibres of the *iliacus* arise from this notch.

The **posterior border** of the ilium presents above the **posterior superior spine,** which gives attachment to the greater sacro-sciatic ligament and the *multifidus spinæ*, and a portion of the oblique sacro-iliac ligament. Below this is a shallow notch terminating below in the **posterior inferior spine,** corresponding to the posterior border of the auricular surface. This spine receives a portion of the greater sacro-sciatic ligament. Below the spine the posterior border of the ilium forms the upper segment of the greater sciatic notch.

The **ischium** consists of a thick solid **body,** a prominent **tuberosity,** and a **ramus.**

The **body** is triangular; its outer surface forms the posterior and inferior section of the acetabulum. The inner surface forms part of the true pelvis, and meets the ilium a little distance below the ilio-pectineal line. It also forms the floor, or non-articular portion, of the acetabulum, and meets the pubes anteriorly; the line of junction is frequently indicated in adult bones by a rough line extending from the **ilio-pubal ridge** to the margin of the obturator foramen. The free border of this surface forms the posterior boundary of the obturator foramen. The inner surface of the ischium gives origin to the *obturator internus*. The posterior surface of the ischium lies between the posterior rim of the acetabulum and the greater sciatic notch. Inferiorly this surface is limited by the **obturator groove,** which receives the posterior fleshy border of the *obturator externus* when the thigh is flexed. The capsule of the hip-joint is attached to the outer part of the posterior surface. The *pyriformis*, the greater and lesser sciatic nerves, the sciatic artery, and the

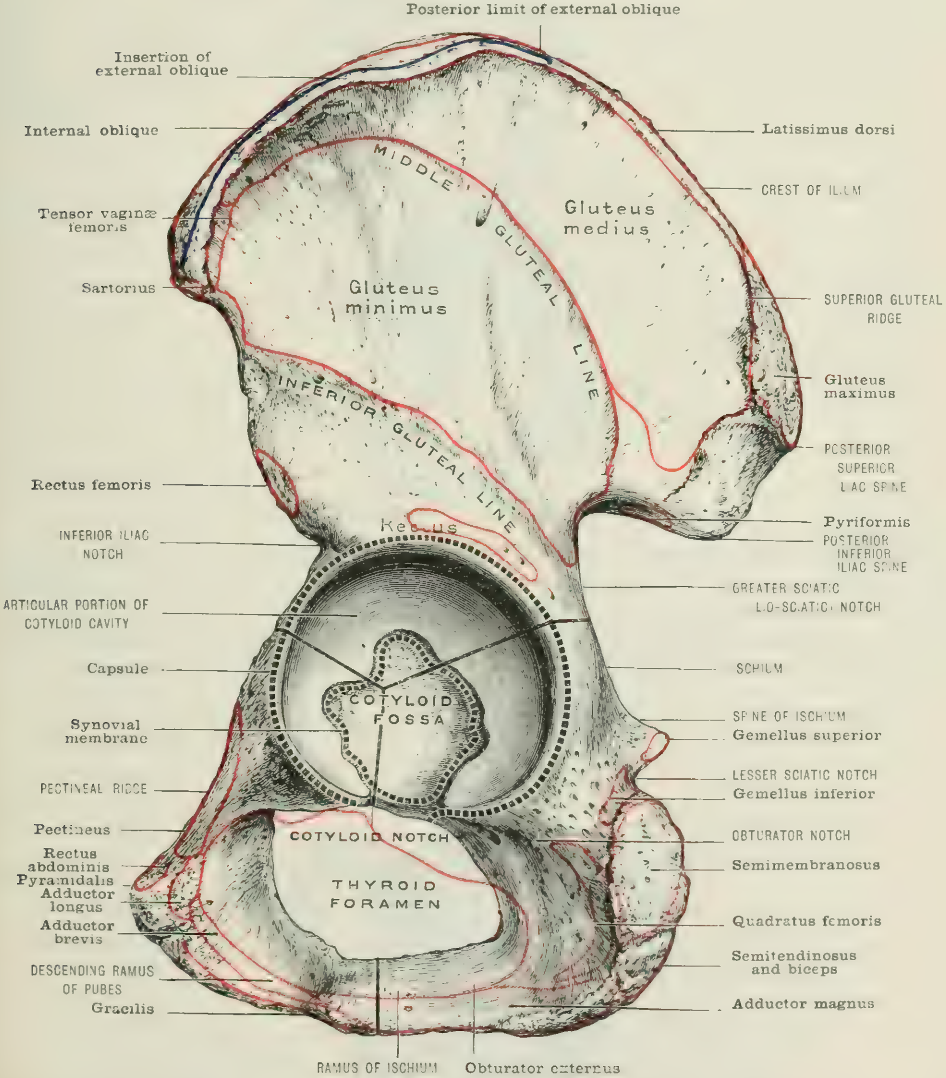
FIG. 151.—THE LEFT HIP-BONE. (Internal surface.)


Quadratus lumborum
Erector spinæ
Transversalis and the iliac fascia
ILIUM
ILIAC FOSSA
Iliacus
Multifidus spinæ
ANT. SUP. SPINE OF ILIUM
AURICULAR SURFACE
POST. INF. SPINE OF ILIUM
ANT. INF. SPINE OF ILIUM
Psoas minor
Obturator internus
ILIO-PUBAL RIDGE
Coccygeus
ISCHIUM
Levator ani
GROOVE FOR OBTURATOR NERVE AND VESSELS
VESSELS AND
THYROID FORAMEN
Gt. sacro-sciatic ligament
PUBES
SYMPHYSIAL SURFACE
Levator ani
Transversus perinei
Crus penis and Erector penis
Compressor urethræ
Subpubic ligament

nerve to the *quadratus femoris*, cross it. The inner border assists the ilium to complete the **greater sciatic notch,** which is terminated inferiorly by the prominent **ischiatic spine,** which gives attachment to the lesser sacro-sciatic ligament, the *levator ani*, and *coccygeus*. From the base of the spine, posteriorly, the *gemellus superior* arises; and the internal pudic vessels and nerve, with the nerve to the obturator internus, cross it. The recess below the ischiatic spine is the **lesser sciatic notch**; in the recent state it is covered with cartilage, and presents two, three, or four grooves for the tendinous under surface of the *obturator internus* muscle.

The **tuberosity** is that portion of the ischium which supports the body in the sitting posture. It is divided into an anterior and a posterior part by a transverse line. The posterior portion is subdivided by an oblique ridge into an upper and outer part for the semimembranosus, and a lower and inner part for the common tendon of the biceps and the semitendinosus. The anterior portion is separated into an inner and outer section by an antero-posterior line, the outer part gives origin to the posterior part of the adductor magnus, and the inner part serves for the attachment of part of the falciform process of the great sacro-sciatic ligament. The surface of the tuberosity above this lip is in relation with the internal pudic vessels and nerves. The outer lip is occupied by the *quadratus femoris* muscle, and the surface adjacent to this is occupied by the *adductor magnus*. The surfaces thin away to a sharp margin, which forms part of the boundary of the obturator foramen.

FIG. 152.—THE LEFT HIP-BONE. (Posterior view.)


Posterior limit of external oblique
Insertion of external oblique
Internal oblique
Tensor vaginæ femoris
Sartorius
Rectus femoris
INFERIOR ILIAC NOTCH
ARTICULAR PORTION OF COTYLOID CAVITY
Capsule
Synovial membrane
PECTINEAL RIDGE
Pectineus
Rectus abdominis
Pyramidalis
Adductor longus
Adductor brevis
DESCENDING RAMUS OF PUBES
Gracilis
RAMUS OF ISCHIUM
Obturator externus
Latissimus dorsi
CREST OF ILIUM
SUPERIOR GLUTEAL RIDGE
Gluteus maximus
POSTERIOR SUPERIOR ILIAC SPINE
Pyriformis
POSTERIOR INFERIOR ILIAC SPINE
GREATER SCIATIC (SACRO-SCIATIC) NOTCH
ISCHIUM
SPINE OF ISCHIUM
Gemellus superior
LESSER SCIATIC NOTCH
Gemellus inferior
OBTURATOR NOTCH
Semimembranosus
Quadratus femoris
Semitendinosus and biceps
Adductor magnus
MIDDLE GLUTEAL LINE
Gluteus medius
Gluteus minimus
INFERIOR GLUTEAL LINE
Rectus
COTYLOID FOSSA
COTYLOID NOTCH
THYROID FORAMEN

The **ramus** of the ischium is a continuation of the tuberosity running upwards to join the descending ramus of the pubes, to complete the obturator foramen. The outer surface of the ramus gives origin to the *adductor magnus* and the *obturator* *externus.* To its inner surface the *crus penis* is attached: it also gives origin to the *transversus perinei,* the *erector penis,* and the *obturator internus.*

The **pubes** consists of a **body** and two **rami.** The body, quadrilateral in shape, is continuous with the ramus of the ischium by means of a flattened process termed the **descending ramus.** The outer surface of the body gives origin to the *adductor longus.* The *adductor brevis,* the *gracilis,* and the *obturator externus* arise from the outer surface of the body and descending ramus. A small portion of the *adductor magnus* also arises from the descending ramus. The posterior surface of the body and that of the descending ramus is continuous with the corresponding surface of the ramus of the ischium, and affords attachment to the *levator ani* and *obturator internus.* The posterior surface of the descending ramus gives origin to the *compressor urethra* and a part of the *erector penis,* the *crus penis,* and the *obturator internus.* The inner border is rough and covered with fibro-cartilage, which unites it with the opposite bone to form the *pubic symphysis.* The outer border forms part of the obturator foramen. The inner border of the descending ramus forms with the ramus of the ischium the pubic arch.

Fig. 153.—An Immature Innominate Bone, showing a Cotyloid Bone.

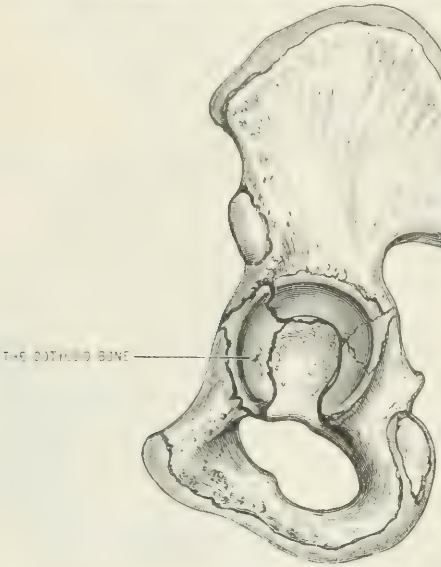
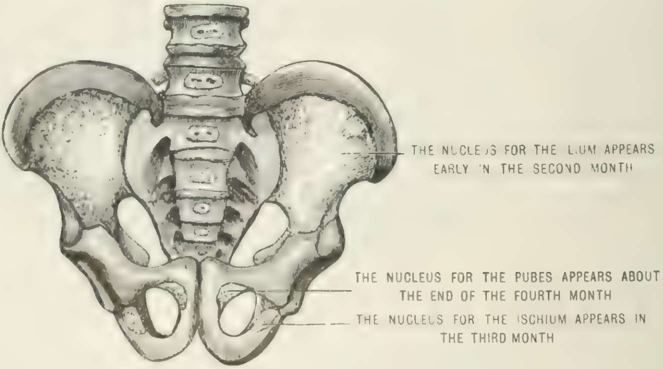

THE COTYLOID BONE

Fig. 154.—The Pelvis of a Fœtus at Birth, to show the Three Portions of the Innominate Bones.


THE NUCLEUS FOR THE ILIUM APPEARS EARLY IN THE SECOND MONTH
THE NUCLEUS FOR THE PUBES APPEARS ABOUT THE END OF THE FOURTH MONTH
THE NUCLEUS FOR THE ISCHIUM APPEARS IN THE THIRD MONTH

The upper surface or **crest** of the pubes is limited externally by the **pubic spine**, which gives attachment to the outer (inferior) pillar of the external abdominal ring or Poupart's ligament. The inner extremity of the crest is the **angle** of the pubes. Between it and the spine the following structures are attached:—the linea alba, the *rectus abdominis*, the *pyramidalis*, and the conjoined tendon of the *internal oblique and transversalis* muscles. The horizontal **ramus** extends from the body of the pubes to the ilium, forming by its outer extremity the anterior one-fifth of the articular surface of the acetabulum. Its line of junction with the ilium forms the **ilio-pubal ridge.** Stretching from this ridge to the pubic spine there is a raised edge continuing the ilio-pectineal line. The surface of bone in front of the line is the **pectineal surface**; it gives origin to the *pectineus* muscle, and is limited below by the **obturator crest,** which extends from the pubic spine to the cotyloid notch. The under surface of the horizontal ramus forms the upper boundary of the obturator foramen, and presents a deep groove for the passage of the obturator vessels and nerve.

The **acetabulum** is a circular depression in which the head of the femur is lodged. It consists of an articular and a non-articular portion. The articular portion is circumferential and horseshoe-shaped; the deficiency is in the lower segment. The pubes forms one-fifth of the acetabulum, and the ischium two-fifths; the rest is formed by the ilium. In rare instances the pubes may be excluded by a fourth element, the **cotyloid bone.** The non-articular portion is formed mainly by the ischium, and is continuous below with the margin of the obturator foramen. The articular portion presents an outer rim to which the cotyloid ligament is attached, and an inner margin to which the synovial membrane is connected which excludes the ligamentum teres from the synovial cavity. The opposite angles of the horseshoe-shaped margin which limit the **cotyloid notch** are united by the transverse ligament, and through the **cotyloid foramen** thus formed a nerve and vessel enter the joint.

The **obturator** (thyroid) **foramen** is situated between the ischium and pubes. Its margins are thin, and serve for the attachment of the obturator foramen. At the upper and posterior angle it is deeply grooved for the passage of the obturator vessels and nerve.

Muscles attached to the **hip-bone** are:—

Gluteus maximus.
Gluteus medius.
Gluteus minimus.
Tensor vaginæ femoris.
Rectus femoris.
Obturator externus.
Obturator internus.
Latissimus dorsi.
Internal oblique.
External oblique.
Transversalis.
Erector spinæ.
Multifidus spinæ.
Quadratus lumborum.
Iliacus.
Psoas parvus.
Quadratus femoris.
Accelerator urinæ (occasionally).
Sartorius.
Pectineus.
Pyramidalis.
Pyriformis.
Gemellus superior.
Gemellus inferior.
Gracilis.
Adductor magnus.
Adductor longus.
Adductor brevis.
Levator ani.
Coccygeus.
Transversus perinei.
Erector penis.
Compressor urethræ.
Biceps femoris.
Semitendinosus.
Semimembranosus.

The **ligaments** attached to the hip-bone are:—

Greater sacro-sciatic.
Lesser sacro-sciatic.
Ilio-lumbar.
Anterior sacro-iliac.
Posterior sacro-iliac.
Capsular and its accessories.
Cotyloid.
Poupart's.
Transverse.
Round (ligamentum teres).
Anterior pubic.
Posterior pubic.
Superior pubic.
Subpubic.
Triangular.

Blood-supply.—The **ilium** receives on its anterior surface, twigs from the ilio-lumbar, deep circumflex iliac, and obturator arteries. On the dorsum, arteries enter it from the gluteal and sciatic trunks.

The **ischium** is supplied by the obturator, internal, and external circumflex.

Fig. 155.—Hip-bone, showing Secondary Centres.

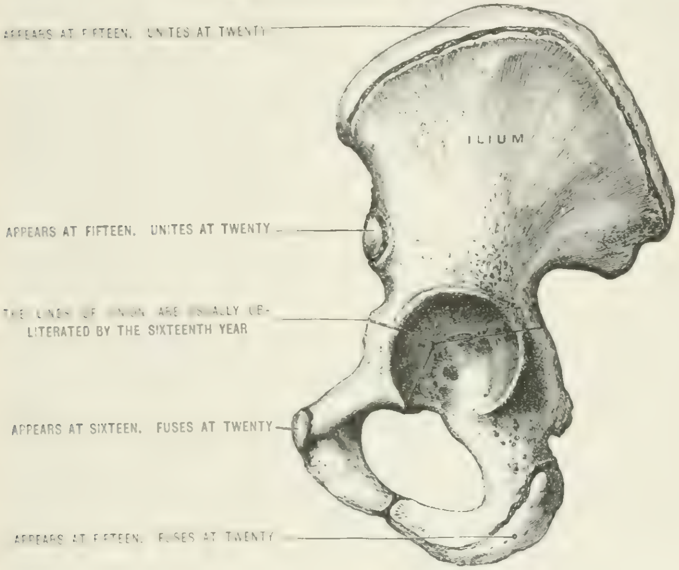
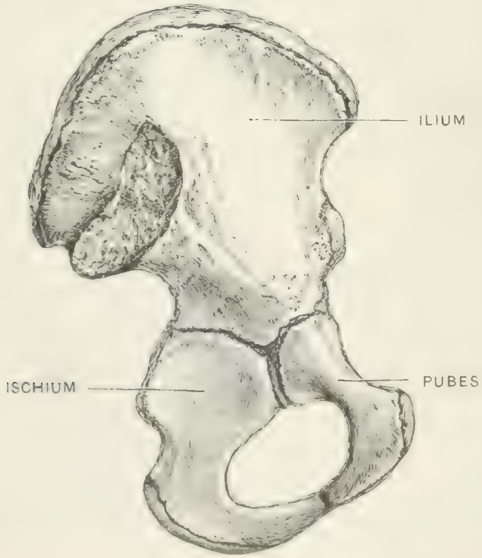

APPEARS AT FIFTEEN. UNITES AT TWENTY
ILIUM
APPEARS AT FIFTEEN. UNITES AT TWENTY
THE LINES OF UNION ARE USUALLY OBLITERATED BY THE SIXTEENTH YEAR
APPEARS AT SIXTEEN. FUSES AT TWENTY
APPEARS AT FIFTEEN. FUSES AT TWENTY

Fig. 156.—Hip-bone (Inner Surface) at the Eighth Year.


ILIUM
ISCHIUM
PUBES

The **pubes** receives twigs from the obturator, internal and external circumflex, deep epigastric, and the pubic branches of the common femoral artery.

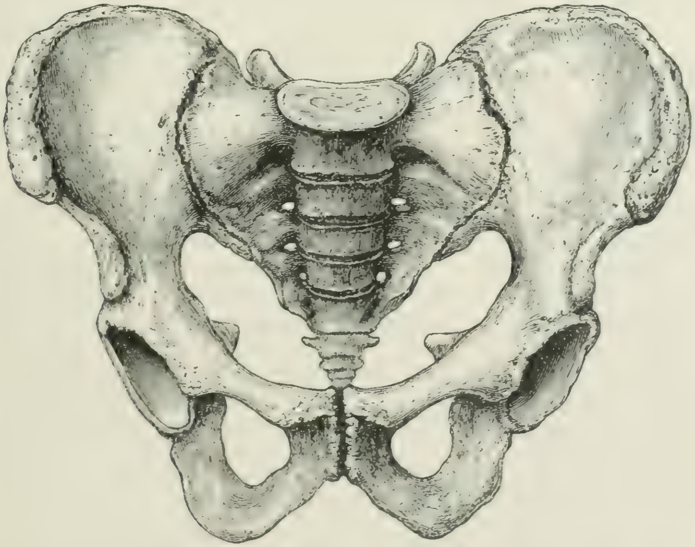
Development.—The cartilaginous representative of the hip-bone consists at first of an **ilio-ischiatic** and a **pubic** segment. These quickly fuse and form a continuous plate. (Rosenberg.) Early in the second month a nucleus appears above the acetabulum for the ilium, and one appears a little later below the cavity for the ischium.

In the fourth month a nucleus is seen in the pubic portion of the cartilage. At birth these three nuclei are of considerable size, but surrounded by relatively wide tracts of cartilage. At the twelfth year the triradiate cartilage which separates the three segments of the innominate bone at the acetabulum begins to ossify by several centres, which unite with the surrounding elements causing their consolidation from the eighteenth to the twentieth year. One of these nuclei is larger than the others and is the acetabular nucleus. The segment it forms is regarded by some morphologists as the representative of the *cotyloid* or *acetabular* bone constantly present in a few mammals, and is of sufficient size to exclude the pubes from the cotyloid cavity. During the eighth year the rami of the ischium and pubes coalesce. About the fifteenth year two secondary nuclei appear in the iliac cartilage to form the crest and the anterior inferior spine. An accessory nucleus appears for the ischial tuberosity, and subsequently one for the pubic crest. These fuse with the main bone about the twentieth year. The fibrous tissue connected with the pubic spine represents the epipubic bone of marsupial mammals.

THE PELVIS

The pelvis is composed of four bones: the two hip-bones, the sacrum, and the coccyx. The hip-bones form the lateral and anterior boundaries, meeting each other to form the pubic symphysis; posteriorly they are separated by the sacrum. The hollow of the pelvis is divided into the **false** and **true** pelvic cavity.

Fig. 157.—The Pelvis (Male).



The **false pelvis** is that part of the cavity which lies above the ilio-pectineal lines; this part is in relation with the hypogastric and inguinal regions.

The **true pelvis** is situated below the ilio-pectineal lines. The upper circumference, called also the **inlet** of the pelvis, is bounded anteriorly by the spine and crest of the pubes, posteriorly by the base of the sacrum, and laterally by the ilio-pectineal lines. The inlet in normal pelves is cordate, being obtusely pointed in front; posteriorly it is encroached upon by the promontory of the sacrum. It has three principal **diameters**; of these, the antero-posterior, called the **conjugate** diameter, is measured from the **sacro-vertebral angle** to the symphysis. The **transverse** diameter represents the greatest width of the pelvic cavity. The **oblique** is measured from the sacro-iliac synchondrosis to the **ilio-pubal** ridge.

The cavity of the true pelvis is bounded in front by the symphysis pubis, behind by the sacrum and coccyx, and laterally by a smooth wall of bone formed in part by the ilium, in part by the ischium; it corresponds to the acetabulum. The cavity is shallow in front, where it is formed by the pubes, and is deepest posteriorly.

The lower circumference, or **outlet,** of the pelvis is very irregular, and encroached upon by three bony processes: the posterior process is the coccyx, and the two lateral processes the ischial tuberosities. They separate three notches. The anterior is the **pubic arch,** and is bounded on each side by the conjoined rami of the pubes and ischium. The two remaining gaps correspond to the greater and lesser sciatic notches; they are bounded by the ischium anteriorly, the sacrum and coccyx posteriorly, and the ilium above. These are converted into foramina by the greater and lesser sacro-sciatic ligaments.

The position of the pelvis.—In the erect position of the skeleton, the plane of the pelvic inlet forms an angle with the horizontal, which varies in individuals from 50° to 60°. The base of the sacrum in an average pelvis lies nearly 10 cm. (4″) above the upper margin of the symphysis pubis.

The axis of the pelvis.—This is an imaginary line drawn at right angles to the planes of the **brim, cavity,** and **outlet,** through their centres.

The average measurements of the diameters of the pelvis in the three planes are given below (after Lusk):—

Diameters	At the brim	At the outlet
Conjugate	4¼ inches	3¾ inches
Transverse	5¼ "	4¼ "
Oblique	5 "	4½ "

Sexual differences :—

Male	Female
Bones heavier and rougher.	Bones more slender.
Ilia less vertical.	Ilia more vertical.
Iliac fossæ deeper.	Iliac fossæ shallower.
False pelvis relatively wider.	False pelvis relatively narrower.
True pelvis deeper.	True pelvis shallower.
" " narrower.	" " wider.
Inlet more heart-shaped.	Inlet more oval.
Symphysis deeper.	Symphysis shallower.
Tuberosities of ischia inflexed.	Tuberosities of ischia everted.
Pubic arch narrower and more pointed.	Pubic arch wider and more rounded.
Margins of ischio-pubic rami more everted.	Margins of ischio-pubic rami less everted.
Obturator foramen oval.	Obturator foramen triangular.
Sacrum narrower and more curved.	Sacrum wider and less curved.
Capacity of true pelvis less.	Capacity of true pelvis greater.

THE FEMUR

This bone is the largest and longest in the skeleton. The upper extremity is surmounted by a hemispherical cartilage-covered articular portion called the **head,** which is directed upwards and inwards, to be received in the acetabulum of the hip-bone. A little below and behind the centre of the head is a small rough depression to which the ligamentum teres is attached. The head is connected to the shaft by the **neck,** a stout rectangular process of bone which forms with the femoral shaft, in the adult, an angle of 125°. Its anterior surface is in the same plane with the front aspect of the shaft, but it is marked off from it by a ridge to which the capsule of the hip-joint is attached. This ridge commences at the greater trochanter in a small prominence, the **superior cervical tubercle,** and extends obliquely downwards to the **inferior cervical tubercle,** and, winding to the back of the femur, becomes continuous with the inner lip of the linea aspera. The whole of this ridge is called the **spiral line,** but the part between the cervical tubercles is often called the **anterior intertrochanteric** line. The superior and inferior tubercles receive the limbs of the ilio-femoral thickening in the capsule of the hip-joint. The posterior surface of the neck is smooth and concave, its inner two-thirds is enclosed in the capsule of the hip-joint. The superior surface is narrow, and pitted with nutrient foramina; it runs downwards to the greater trochanter. The inferior surface, concave in outline, terminates at the lesser trochanter.

The **trochanters** are prominences which afford attachment to muscles which rotate the thigh; they are two in number, the greater and the lesser.

The **greater trochanter** is quadrilateral, and surmounts the junction of the neck with the shaft. Of its two surfaces, the external is the broader; it is bisected diagonally by a ridge running from the posterior superior to the anterior inferior angle. The *gluteus medius* is inserted into this ridge; a bursa occasionally is interposed between the tendon and the bone. The inner surface presents a deep pit, the **trochanteric fossa,** which receives the tendon of the *obturator externus.* The upper border, called the **tip,** gives attachment from before backwards to the tendons of the *obturator internus* with the *gemelli*, and the *pyriformis.* The anterior border receives the *gluteus minimus.* The posterior border is thick, rounded, and continuous with the **posterior intertrochanteric line,** which runs downwards to terminate at the **lesser trochanter,** a conical prominence on the posterior aspect of the femur to which the *psoas* is inserted. Running downwards from the lesser trochanter to meet the spiral line is a slender ridge, to which the *iliacus* is inserted. The surface of bone slightly posterior to this ridge is occupied by the *pectineus.* This part of the femur presents several converging ridges, which will be most conveniently considered with the linea aspera.

The **shaft** of the femur is cylindrical in shape, and presents, in the middle third of its posterior aspect, a prominent vertical ridge of bone, the **linea aspera,** for the origin and insertion of muscles. In the middle of the shaft the linea aspera presents an inner lip, an outer lip, and an intervening space. Towards the upper third of the shaft these three parts diverge: the outer lip becomes continuous with the **gluteal ridge,** and ends at the base of the greater trochanter. When very prominent the gluteal ridge is termed the **third trochanter.** It affords attachment to the *gluteus maximus.* The inner lip curves inwards below the lesser trochanter, and becomes the **spiral line.** The middle portion of the linea aspera bifurcates, the inner portion as it runs on to the lesser trochanter receives the *iliacus;* the outer passes upwards to the centre of the posterior intertrochanteric line; it receives the *quadratus femoris*, and is called the **linea quadrati.** The upper limit of this line is often indicated by a rounded tubercle which projects on the posterior intertrochanteric line. Towards the lower third of the shaft, the inner and outer lips of the linea aspera diverge to become continuous with the condylar ridges. Several muscles are connected with the linea aspera. The *vastus internus* arises from the whole length of the inner lip, and the *vastus externus* from the outer lip. The *adductor magnus* is inserted into the upper half of the outer lip, and the lower half

Fig. 158.—The Left Femur. (Anterior view.)

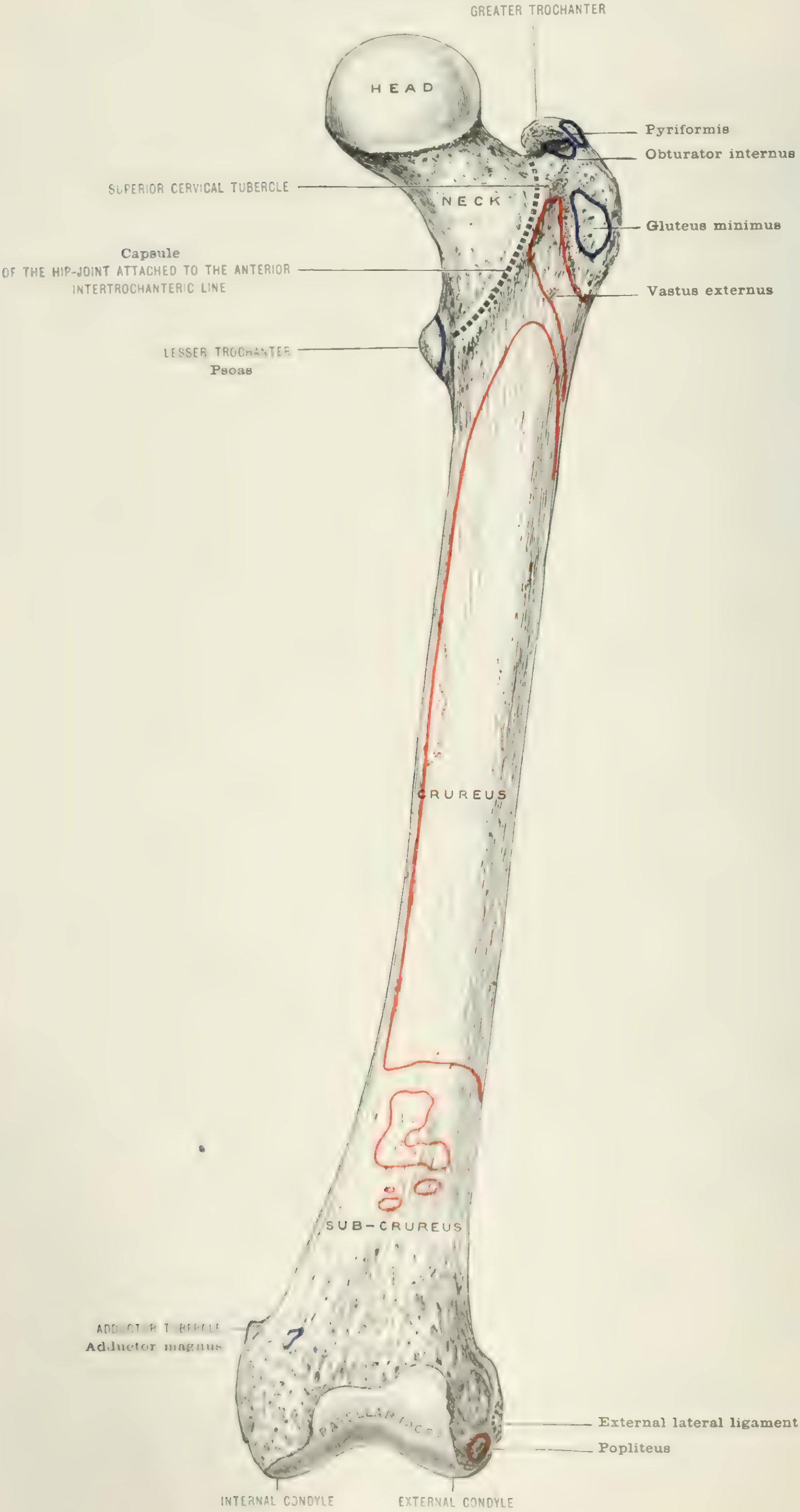
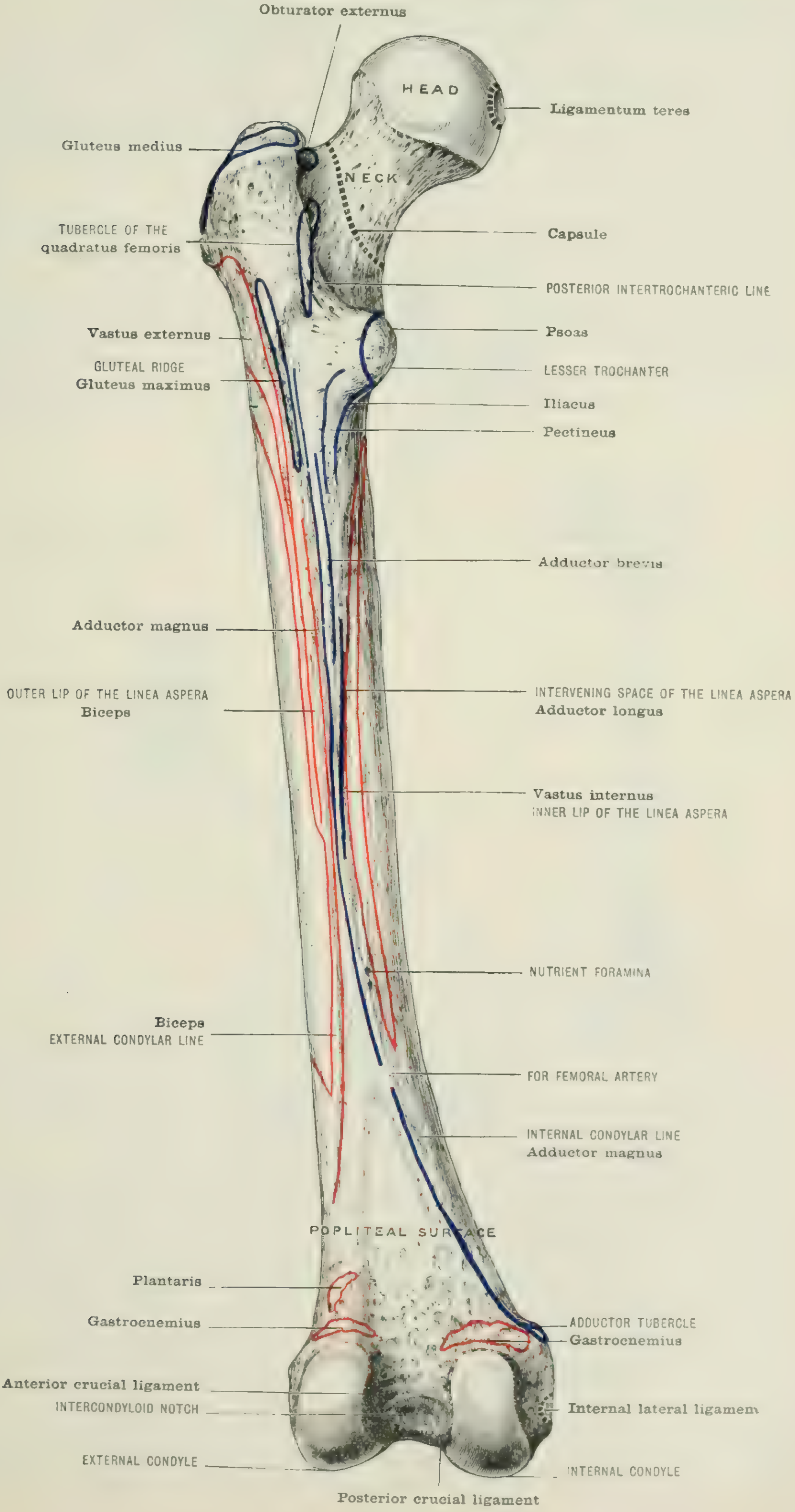
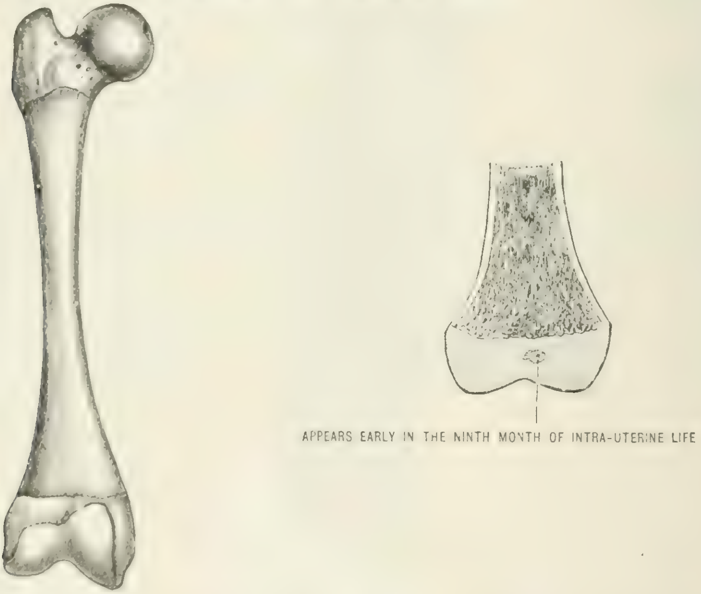

GREATER TROCHANTER
HEAD
Pyriformis
Obturator internus
SUPERIOR CERVICAL TUBERCLE
NECK
Gluteus minimus
Capsule
OF THE HIP-JOINT ATTACHED TO THE ANTERIOR INTERTROCHANTERIC LINE
Vastus externus
LESSER TROCHANTER
Psoas
CRUREUS
SUB-CRUREUS
ADDUCTOR TUBERCLE
Adductor magnus
PATELLAR SURFACE
External lateral ligament
Popliteus
INTERNAL CONDYLE
EXTERNAL CONDYLE

Fig. 159.—The Left Femur. (Posterior view.)


Obturator externus
HEAD
Ligamentum teres
Gluteus medius
NECK
TUBERCLE OF THE quadratus femoris
Capsule
POSTERIOR INTERTROCHANTERIC LINE
Vastus externus
Psoas
GLUTEAL RIDGE Gluteus maximus
LESSER TROCHANTER
Iliacus
Pectineus
Adductor brevis
Adductor magnus
OUTER LIP OF THE LINEA ASPERA Biceps
INTERVENING SPACE OF THE LINEA ASPERA Adductor longus
Vastus internus
INNER LIP OF THE LINEA ASPERA
NUTRIENT FORAMINA
Biceps
EXTERNAL CONDYLAR LINE
FOR FEMORAL ARTERY
INTERNAL CONDYLAR LINE
Adductor magnus
POPLITEAL SURFACE
Plantaris
Gastrocnemius
ADDUCTOR TUBERCLE
Gastrocnemius
Anterior crucial ligament
INTERCONDYLOID NOTCH
Internal lateral ligament
EXTERNAL CONDYLE
INTERNAL CONDYLE
Posterior crucial ligament

of the inner lip. The *adductor longus* and *brevis* are inserted into the intervening space; the adductor longus takes rather more than the middle third, and overlaps the lower part of the adductor brevis, which takes rather more than the upper third. The outer lip in its lower two-thirds gives origin to the shorter head of the *biceps*. The **condylar lines** are two in number; the **outer** is continuous with the outer lip of the linea aspera and terminates inferiorly on the outer edge of the external condyle. From the upper half of this line a part of the short head of the *biceps* arises. Near its termination the line expands to give origin to the *plantaris* and the outer head of the *gastrocnemius*. The **inner** condylar line is not so prominent as the outer; it is continuous with the inner lip of the linea aspera, and terminates at the **adductor tubercle.** The *adductor magnus* is inserted into the whole length of the line and to the tubercle. Near the middle of the line there is an interruption where the femoral artery passes through the opening in the tendon of the adductor magnus. The inner head of the gastrocnemius arises from the femur immediately above the internal condyle. The space enclosed between these diverging lines forms part of the anterior boundary of the popliteal space, and is in close relation with the popliteal vessels. The shaft of the femur is overlapped on the inner side by the *vastus internus*, and on the outer side it gives origin in the upper three-fourths to the *crureus* and is overlapped by the *vastus externus*. The upper three-fourths of the anterior surface serves for the origin of the crureus, and the lower fourth gives attachment to the subcrureus.

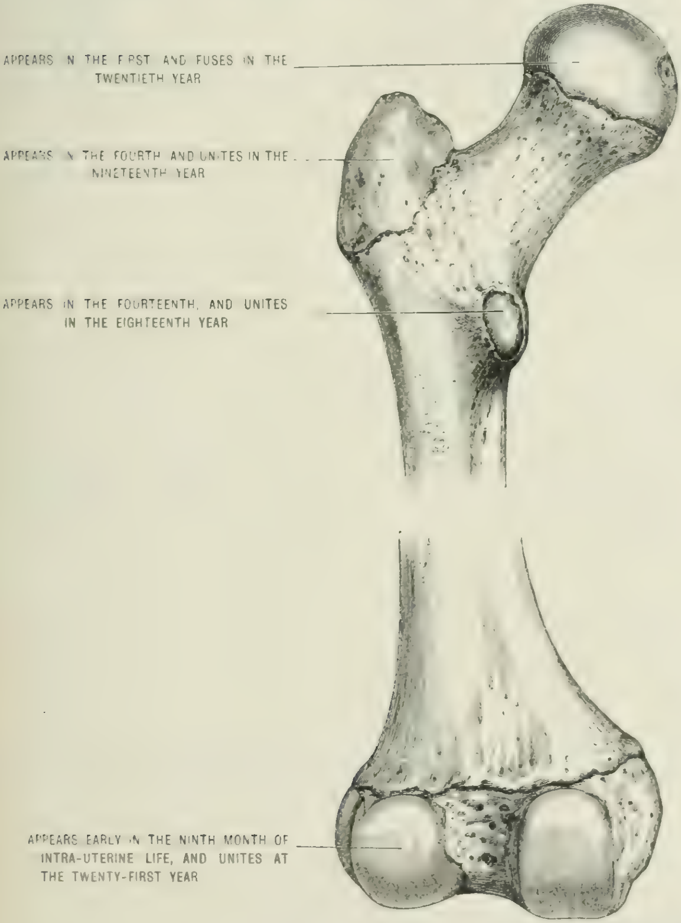
Fig. 160.—The Femur at Birth.



The lower extremity presents two cartilage-covered **condyles,** separated by a deep notch. The **external condyle** is more prominent anteriorly and wider than its fellow. The **internal** is more prominent posteriorly, and narrower; it is also longer, to compensate for the obliquity of the shaft. When the femur is properly articulated, the inferior surfaces of the condyles are nearly on the same plane, and almost parallel to come into contact with the articular surfaces on the head of the tibia. Posteriorly the condyles are separated by a deep pit or notch; anteriorly they are united by an articular surface, over which the patella glides. The inner surface of the internal condyle has, near its posterior border, a rough surface for the internal lateral ligament of the knee-joint; above this is the adductor tubercle. The surface of this condyle, which bounds the **intercondyloid notch,** affords attachment, near the anterior border, to the posterior crucial ligament. The surface of the external condyle which bounds the notch gives attachment, at its posterior part, to the anterior crucial ligament. The outer surface of the external condyle presents near the lower and posterior margin a deep groove, which receives the tendon of the *popliteus* muscle when the leg is flexed. The anterior end of the groove terminates in a pit which gives origin to the popliteus tendon. The groove is surmounted by a tubercle for the external lateral ligament of the knee.

The **patellar facet** is trochlear in shape; its outer portion is more extensive than the inner, corresponding to the disposition of the articular facets on the posterior surface of the patella.

Fig. 161.—The Left Femur at the Twentieth Year. (Posterior view.)


APPEARS IN THE FIRST AND FUSES IN THE TWENTIETH YEAR
APPEARS IN THE FOURTH AND UNITES IN THE NINETEENTH YEAR
APPEARS IN THE FOURTEENTH, AND UNITES IN THE EIGHTEENTH YEAR
APPEARS EARLY IN THE NINTH MONTH OF INTRA-UTERINE LIFE, AND UNITES AT THE TWENTY-FIRST YEAR

Muscles attached to the femur: —

Pyriformis.
Obturator internus and gemelli.
Obturator externus.
Pectineus.
Quadratus femoris.
Gluteus maximus.
Gluteus medius.
Gluteus minimus.
Psoas.
Iliacus.
Adductor brevis.
Vastus internus.
Adductor magnus.
Adductor longus.
Vastus externus.
Crureus and subcrureus.
Biceps.
Gastrocnemius.
Plantaris.
Popliteus.

Ligaments :—

Capsular of hip-joint.
Ligamentum teres.
Internal lateral of knee-joint.
External lateral of knee-joint.
Anterior crucial.
Posterior crucial.
Posterior, or Winslow's.

Blood-supply.—The head and neck of the femur receive branches from the sciatic, obturator, and circumflex arteries. The trochanter receives twigs from the circumflex arteries. The nutrient vessel for the shaft is derived from the second perforating; it enters near the middle of the linea aspera, and is directed towards the head of the bone. The condyles are nourished by articular branches from the popliteal and the anastomotic of the femoral.

Ossification.—The shaft of the femur begins to ossify in the seventh week of intra-uterine life. Early in the ninth month a nucleus appears for the condyles. During the first year the nucleus for the head of the bone is visible, and one for the greater trochanter in the fourth year. The centre for the lesser trochanter is visible about the thirteenth or fourteenth year. The lesser trochanter joins the shaft at the eighteenth, the greater trochanter at the nineteenth, the head about the twentieth, and the condyles at the twenty-first year.

The neck of the femur is an *apophysis*, or outgrowth from the shaft. The line of fusion of the condyloid epiphysis passes through the adductor tubercle.

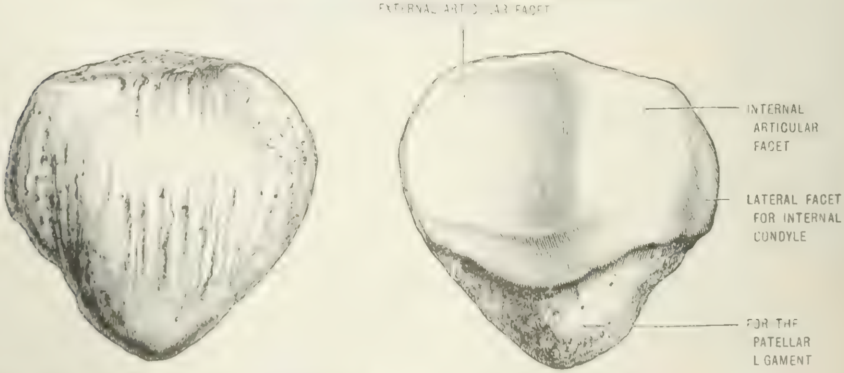
The morphological relation of the patellar facet to the articular portions of the condyles is worth notice. In a few mammals, such as the ox, this facet remains separated from the condyles by a furrow of rough bone. In the human femur it is faintly marked off by a shallow groove in the cartilage, best seen in a recently opened knee-joint. Some anatomists attribute these grooves in the cartilage to the pressure of the semilunar fibro-cartilages.

The angle which the neck of the femur forms with the shaft measures at birth, on an average, 160°. In the adult it varies from 110° to 140°; hence the angle decreases greatly during the period of growth. When once growth is completed, the angle, as a rule, remains fixed. (Humphry.)

THE PATELLA

The **patella** is a sesamoid bone, somewhat triangular in shape, situated in front of the knee-joint. Its anterior surface is slightly convex, and pitted with

FIG. 162.—THE LEFT PATELLA.


Anterior surface
Posterior surface

small openings, which transmit nutrient vessels to the interior of the bone. This surface is subcutaneous; a bursa intervenes between it and the skin. The posterior surface is concave, and in great part cartilage-covered, forming a compound articular surface for gliding upon the femoral condyles. A slightly marked vertical ridge divides this surface into an outer larger portion for the external condyle, and an inner portion for the internal condyle. A slender articular facet close to the inner edge is sometimes marked off by a faint vertical ridge; this facet comes in contact with the internal condyle in extreme flexion of the leg. The lower part of the bone is terminated by a blunt point, which is embedded in the patellar ligament, especially on the posterior aspect. The upper two-thirds of the circumference receives directly the fibres of the *vastus internus* and *externus*, the *crureus* and *rectus femoris* muscles.

Blood-supply.—The patella receives twigs from the superficial branch of the anastomotica, anterior tibial recurrent, and the inferior articular of the popliteal.

Ossification.—The cartilage for the patella appears in the fourth month of intra-uterine life. The ossific nucleus is visible in the third year.

THE TIBIA

The tibia is the larger bone of the leg; it is situated on the inner side of, and nearly parallel with, the fibula. The upper extremity, or **head,** consists of two lateral eminences, or **tuberosities.** The superior surfaces of the tuberosities receive the condyles of the femur, the articular surfaces being separated by a non-articular ridge, to which ligaments are attached. The **internal articular** surface is oval in shape and concave for the internal condyle of the femur. The **external articular** surface is smaller, somewhat circular in shape, and presents an almost plane surface for the external condyle. The peripheral portion of each articular surface is overlaid by a fibro-cartilage of semilunar shape, connected with the margins of the tuberosities by bands of fibrous tissue termed coronary ligaments. Each semilunar fibro-cartilage is attached firmly to the rough tract separating the articular surfaces. This intermediate space is broad and depressed in front, where it affords attachment to the anterior limb of the internal and external semilunar cartilages and the anterior crucial ligament. Projecting upwards from the middle of this surface is the **spine** of the tibia. The posterior aspect of the base of the spine affords attachment to the posterior limb of the external and internal semilunar fibro-cartilages, and limits a deep notch inclined towards the inner tuberosity; this notch gives origin to the posterior crucial ligament. Anteriorly, the two tuberosities are confluent, and form a somewhat flattened surface of triangular outline; its apex forms the **tubercle** of the tibia. The ligamentum patellæ is inserted into the lower part of the tubercle; the upper part is smooth and separated from the ligament by a bursa. Laterally, the inner tuberosity is less prominent though more extensive than the outer; near the posterior part of its circumference there is a deep horizontal groove for the central portion of the semimembranosus tendon. The margins of this groove and the surface of bone below give attachment to the internal lateral ligament of the knee. At a corresponding point of the outer tuberosity there is a rounded articular facet for the head of the fibula; the circumference of the facet is rough for ligaments. Above and in front of it is a ridge for the ilio-tibial band.

The **shaft** is prismatic, and very thick near the head; towards the lower third it is thinner and tapering, and gradually expands towards the lower end. It has three **borders**: the **anterior** is very prominent, and known as the **crest** of the **tibia**: commencing on the outer edge of the tubercle, it runs downwards and curves inwards, to terminate at the anterior margin of the **malleolus.** This border gives attachment to the deep fascia of the leg. The **internal border** starts from the back of the internal tuberosity, and ends at the posterior margin of the malleolus.

FIG. 163.—THE LEFT TIBIA AND FIBULA. (Anterior view.)

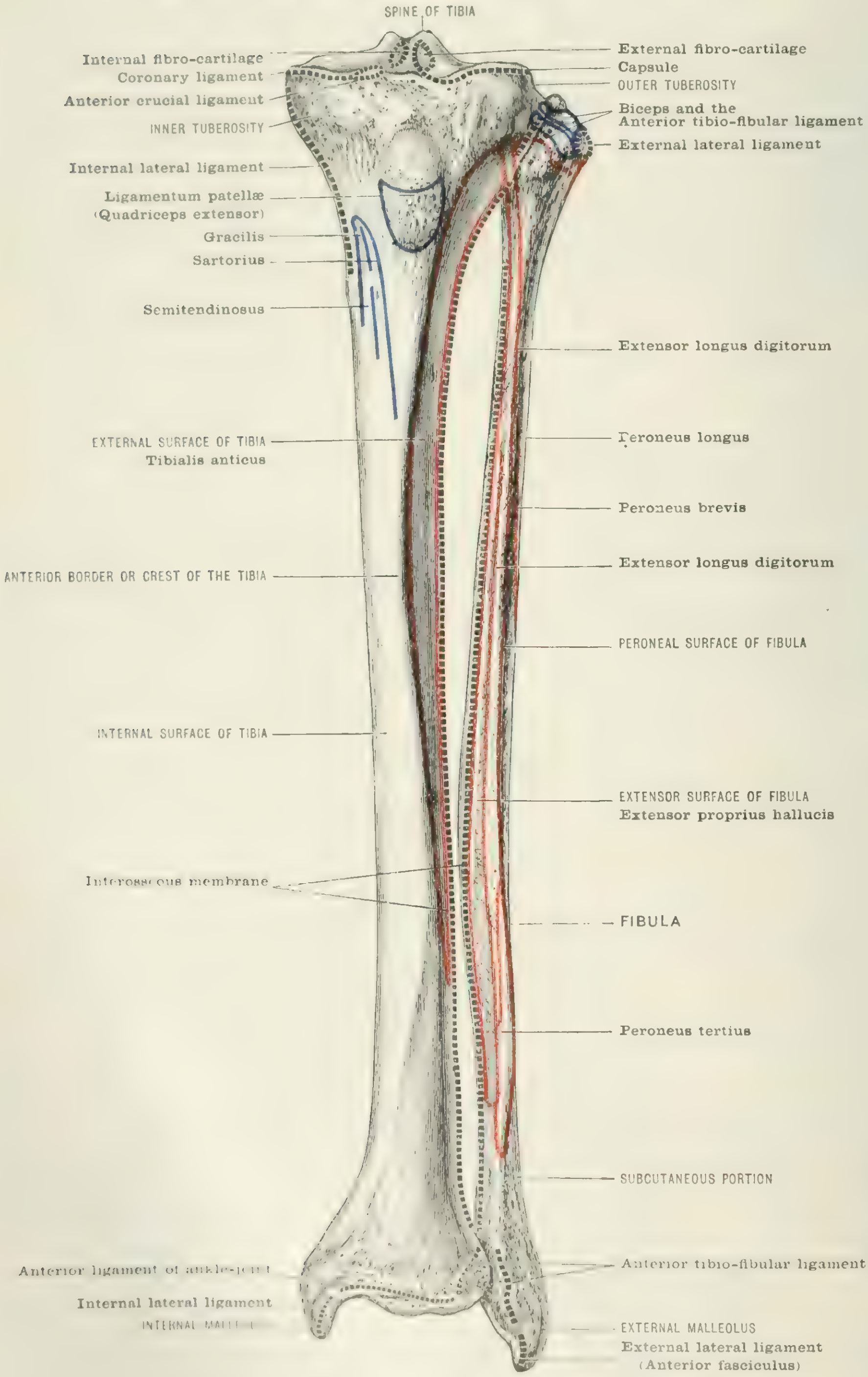
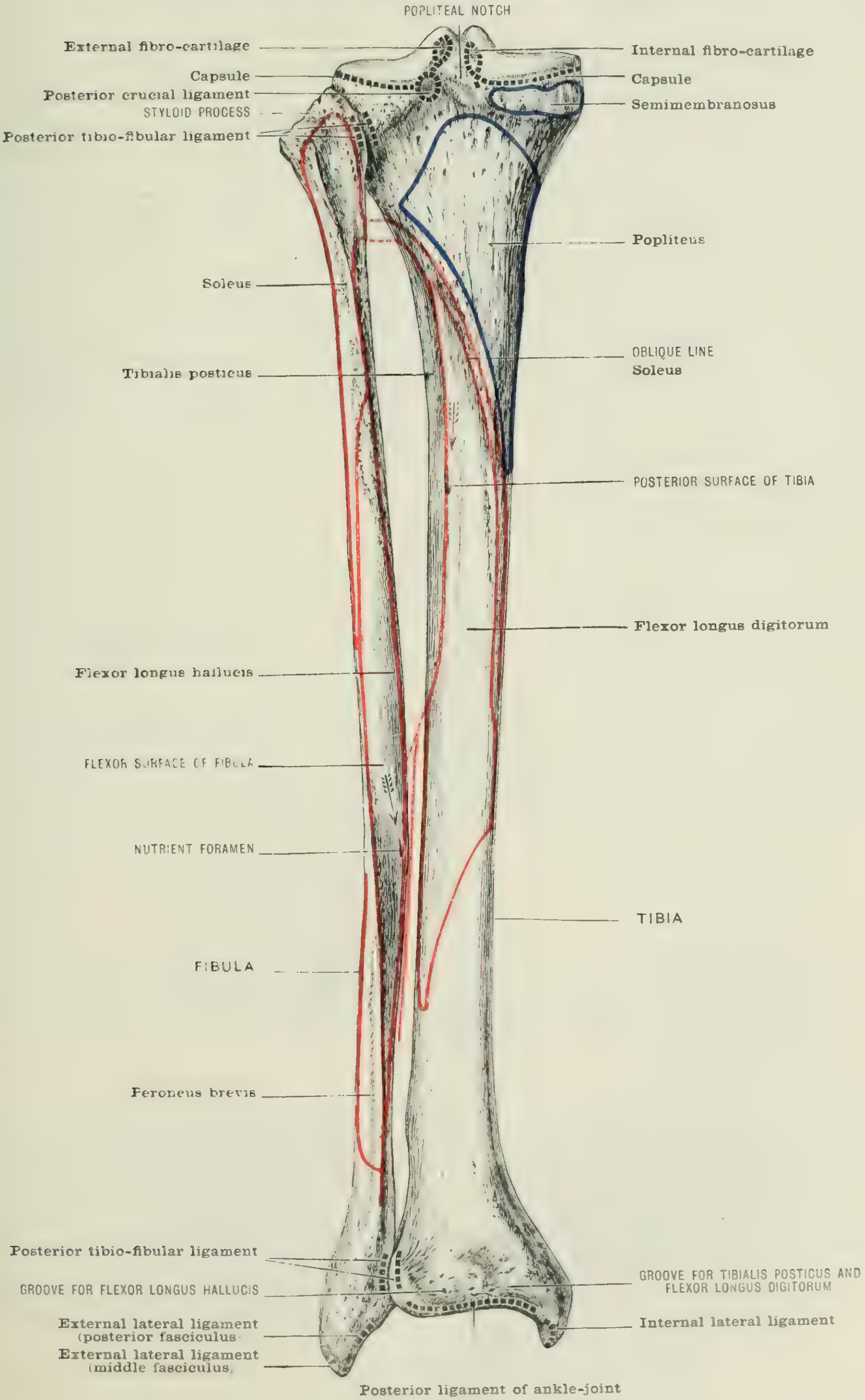

SPINE OF TIBIA
Internal fibro-cartilage
External fibro-cartilage
Coronary ligament
Capsule
OUTER TUBEROSITY
Anterior crucial ligament
Biceps and the Anterior tibio-fibular ligament
INNER TUBEROSITY
External lateral ligament
Internal lateral ligament
Ligamentum patellæ (Quadriceps extensor)
Gracilis
Sartorius
Semitendinosus
Extensor longus digitorum
EXTERNAL SURFACE OF TIBIA
Tibialis anticus
Peroneus longus
Peroneus brevis
Extensor longus digitorum
ANTERIOR BORDER OR CREST OF THE TIBIA
PERONEAL SURFACE OF FIBULA
INTERNAL SURFACE OF TIBIA
EXTENSOR SURFACE OF FIBULA
Extensor proprius hallucis
Interosseous membrane
FIBULA
Peroneus tertius
SUBCUTANEOUS PORTION
Anterior ligament of ankle-joint
Anterior tibio-fibular ligament
Internal lateral ligament
INTERNAL MALLEOLUS
EXTERNAL MALLEOLUS
External lateral ligament (Anterior fasciculus)

FIG. 164.—THE LEFT TIBIA AND FIBULA. (Posterior view.)


POPLITEAL NOTCH
External fibro-cartilage
Capsule
Posterior crucial ligament
STYLOID PROCESS
Posterior tibio-fibular ligament
Internal fibro-cartilage
Capsule
Semimembranosus
Popliteus
Soleus
OBLIQUE LINE
Soleus
Tibialis posticus
POSTERIOR SURFACE OF TIBIA
Flexor longus digitorum
Flexor longus hallucis
FLEXOR SURFACE OF FIBULA
NUTRIENT FORAMEN
TIBIA
FIBULA
Peroneus brevis
Posterior tibio-fibular ligament
GROOVE FOR FLEXOR LONGUS HALLUCIS
GROOVE FOR TIBIALIS POSTICUS AND FLEXOR LONGUS DIGITORUM
External lateral ligament (posterior fasciculus)
External lateral ligament (middle fasciculus)
Internal lateral ligament
Posterior ligament of ankle-joint

The internal lateral ligament is attached to its upper 7·5 cm. (3″), and the middle third gives origin to the *soleus*. The **interosseous border** extends from the fibular facet on the outer tuberosity to the lower end of the bone; towards its termination the border bifurcates to enclose a triangular space for the attachment of the interosseous ligament between the tibia and fibula. The part above the bifurcation is connected with the interosseous membrane.

These borders limit three surfaces. The **internal surface** is bounded by the internal border and the crest; it is broad above, where it receives the insertion of the *sartorius*, *gracilis*, and *semitendinosus*; the rest of the surface is convex and subcutaneous. The **external surface** lies between the crest of the tibia and the interosseous border. The upper two-thirds presents a hollow for the origin of the *tibialis anticus*; the rest of the surface is overlaid by the extensor tendons and the anterior tibial vessels. The **posterior surface** is limited by the interosseous ridge and the internal border. The upper part presents a rough **oblique ridge,** extending from the fibular facet on the outer tuberosity to the internal border, a little above the middle of the bone. This oblique ridge gives origin to the *soleus* and attachment to the popliteal fascia; the surface above is for the insertion of the *popliteus*. An indefinite vertical ridge commences near the middle of the oblique line, and marks off a semilunar space, limited externally by the interosseous border. This is for the *tibialis posticus*; it extends as low as the junction of the middle and lower thirds. The portion of bone inside this vertical line is for the *flexor longus digitorum*. The lower third of the posterior surface is covered by flexor tendons.

The **inferior extremity** is somewhat quadrilateral, and resembles the distal end of the radius. Its inferior surface is articular for the upper surface of the astragalus and is continuous with the external surface of the malleolus, which articulates with the facet on the inner side of the astragalus. The outer surface has a triangular rough area for the lower end of the shaft of the fibula, its margins being rough for ligaments. The anterior border is slightly convex, and by its margin gives attachment to the anterior ligament of the ankle. The posterior surface has two grooves: the one which encroaches on the malleolus is for the tendons of *tibialis posticus* and *flexor longus digitorum*, and an outer shallow groove for the tendon of *flexor longus hallucis*. The inner surface is prolonged downwards to form the **malleolus**; from its tip and margins the internal lateral (deltoid) ligament of the ankle-joint arises. The inner surface of the malleolus is convex and subcutaneous; the outer, as already stated, has a facet for the inner surface of the astragalus.

The tibia affords attachment to the following **muscles**:—

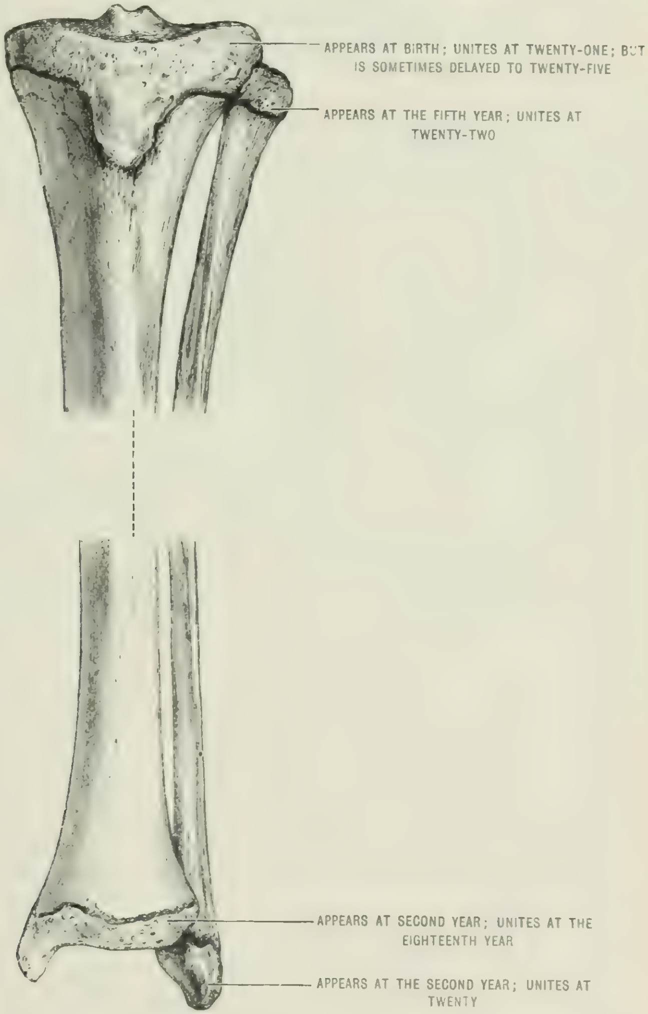
Semimembranosus.
Sartorius.
Gracilis.
Semitendinosus.
Quadriceps extensor.
Popliteus.
Tensor vaginæ femoris (indirectly).
Tibialis posticus.
Tibialis anticus.
Soleus.
Peroneus longus.
Flexor longus digitorum.
Extensor longus digitorum.
Biceps femoris.

Ligaments:—

Anterior crucial.
Posterior crucial.
Internal lateral of the knee.
Internal semilunar cartilage.
External semilunar cartilage.
Anterior tibio-fibular (inferior).
Posterior tibio-fibular (inferior).
Anterior of ankle.
Anterior annular (transverse).
Coronary.
Anterior tibio-fibular (superior).
Posterior tibio-fibular (superior).
Ilio-tibial band.
Interosseous membrane.
Anterior annular (oblique).
Internal annular.
Internal lateral of ankle (deltoid).
Posterior (of ankle).
Transverse.

Blood-supply.—The tibia is a very vascular bone. The nutrient artery for the shaft is furnished by the posterior tibial; it enters the bone near the interosseous border at the junction of the upper and middle thirds, and is directed downwards. The head of the bone receives numerous branches from the inferior articular arteries of the popliteal, and the recurrent branches of the anterior and posterior tibial arteries. The lower extremity receives twigs from the posterior and anterior tibial, the anterior peroneal, and internal malleolar arteries.

Fig. 165.—The Tibia and Fibula at the Sixteenth Year.


APPEARS AT BIRTH; UNITES AT TWENTY-ONE; BUT IS SOMETIMES DELAYED TO TWENTY-FIVE
APPEARS AT THE FIFTH YEAR; UNITES AT TWENTY-TWO
APPEARS AT SECOND YEAR; UNITES AT THE EIGHTEENTH YEAR
APPEARS AT THE SECOND YEAR; UNITES AT TWENTY

Ossification.—The centre for the shaft of the tibia appears in the eighth week of intra-uterine life. Towards the end of the ninth month, a small earthy nucleus appears in the cartilaginous head of the tibia. The nucleus for the lower extremity appears in the second year, and unites with the shaft at eighteen. The epiphysis for the head of the bone is one of the last to unite with its shaft: this event usually occurs about the twenty-first year, but may be delayed until twenty-five. The tubercle of the tibia is usually ossified from the epiphysis: occasionally it has an independent nucleus.

THE FIBULA

This is a long slender bone lying postero-externally in the leg, to the outer side of and somewhat posterior to the tibia, with which it articulates both above and below. It is excluded from the knee-joint but forms the outer boundary of the ankle-joint.

The upper extremity, or **head**, is a rounded prominence. Its upper surface is rough externally for the attachment of the biceps tendon and the long external lateral ligament of the knee-joint; internally it presents a round or oval articular facet for the outer tuberosity of the tibia; the margins of this facet give attachment to the capsular ligament of the superior tibio-fibular articulation. Posteriorly, it rises into a pointed process, the **styloid process,** which gives attachment at its apex to the short external lateral ligament of the knee and laterally to part of the biceps tendon. The posterior aspect of the head gives attachment to the *soleus*, the outer to the *peroneus longus*, the anterior to the *extensor longus digitorum*, and the inner lies adjacent to the tibia.

The lower extremity, **external malleolus,** is a triangular piece of bone placed with the base uppermost. Its outer surface is convex and subcutaneous. The inner surface is divided into an anterior and upper area, triangular in outline and convex from above downwards for articulation with the outer side of the astragalus, and a lower and posterior excavated area, the **digital fossa,** in which are attached the transverse inferior tibio-fibular ligament and the posterior band of the external lateral ligament of the ankle. The anterior border is rough; it gives attachment to the anterior band of the external lateral ligament of the ankle, the anterior inferior tibio-tibular ligament, and the anterior annular ligament. The posterior border is grooved for the peronei tendons, and the apex gives attachment to the middle band of the external lateral ligament of the ankle.

The **shaft** is quadrangular, possessing four borders and surfaces. The **antero-external border** commences in front of the head and terminates below by dividing to enclose the subcutaneous surface on the outer side of the external malleolus. The **antero-internal border** also commences in front of the head, close to the antero-external border; it terminates below by dividing to enclose a rough triangular area immediately above the facet for the astragalus; this area gives attachment to the inferior interosseous ligament, and sometimes bears at its lower end a narrow facet for the tibia. The **postero-internal border** commences at the inner side of the head and terminates below by joining the antero-internal border at the upper part of the lower fourth of the shaft. The postero-external border runs from the back of the head to the inner border of the peroneal groove on the back of the lower extremity; it gives attachment to the fascia separating the peronei and the flexor muscles.

The **anterior** or extensor surface between the antero-internal and antero-external borders is narrow above but broader below; three muscles spring from it: externally in the upper two-thirds the *extensor longus digitorum*, and in the lower third the *peroneus tertius;* internally in the middle third the *extensor longus hallucis*. The **internal surface** between the antero- and postero-internal borders is usually concave; it is narrow above and below, and broadest in the middle; it is frequently crossed by one or more oblique ridges, and it gives attachment to the *tibialis posticus*. The **posterior surface** between the postero-internal and external borders is twisted; it looks backwards above and inwards below; in its upper third it gives attachment to the *soleus* and in the lower two-thirds to the *flexor longus hallucis*. The **external surface** between the antero- and postero-external borders is also twisted, looking outwards above and backwards below, where it is continuous with the groove on the peronei tendons; it gives attachment in its upper two-thirds to the *peroneus longus* and in the lower two-thirds to the *peroneus brevis*.

The **muscles** arising from the fibula are:—

Soleus.
Tibialis posticus.
Peroneus tertius.
Flexor longus hallucis.

Peroneus longus.
Peroneus brevis.
Extensor longus digitorum.
Extensor proprius hallucis.

The fibula affords insertion to the biceps.

The following **ligaments** are connected with it:—

External lateral of the knee.
Anterior tibio-fibular.
Posterior tibio-fibular.
Interosseous membrane.
External lateral ligament of ankle.
Transverse.
Anterior tibio-fibular (inferior).
Posterior tibio-fibular.
External annular.
Anterior annular (vertical).

Blood-supply.—The fibula receives the nutrient artery of its shaft from the peroneal branch of the posterior tibial. The head is nourished by branches from the inferior external articular branch of the popliteal artery, and the malleolus is supplied mainly by the peroneal, anterior peroneal, and external malleolar arteries.

Ossification.—The shaft of the fibula commences to ossify in the eighth week of intra-uterine life. A nucleus appears for the lower in the second year, and one in the fifth year for the upper extremity. The lower extremity fuses with the shaft about twenty, but the upper one remains separate until the twenty-second year.

The human fibula differs from all others in the excessive length of its malleolus; in no other vertebrate does this process descend below the level of the tibial malleolus. In the majority of mammals the tibial descends to a lower level than the fibular malleolus. In the human embryo of the fourth month, the outer (fibular) is very much smaller than the inner (tibial) malleolus. At the seventh month they are equal in length; at birth, the fibular malleolus is the longer; and by the second year it assumes its adult proportion. (Gegenbaur.)

The fibula is a vestigial bone in man, and survives mainly on account of the excessive development of its malleolus. This accounts for the fact that the lower epiphysis, though appearing first, unites with the shaft before the upper epiphysis. In birds, the head of the bone is large, and enters into the formation of the knee-joint, whilst the lower end atrophies.

THE FOOT

The bones comprised in the skeleton of the foot are arranged in three groups:—**tarsus, metatarsus,** and **phalanges.**

The tarsus consists of seven bones:—The astragalus, os calcis or calcaneum, scaphoid, cuboid, and three cuneiform bones.

THE ASTRAGALUS

This bone may, for descriptive purposes, be divided into a **body, neck,** and **head.** The **body** is quadrilateral. Its upper aspect resembles a segment of the wheel of a pulley; hence it is called the **trochlear** surface. It is broader in front than behind, and articulates with the lower end of the tibia.

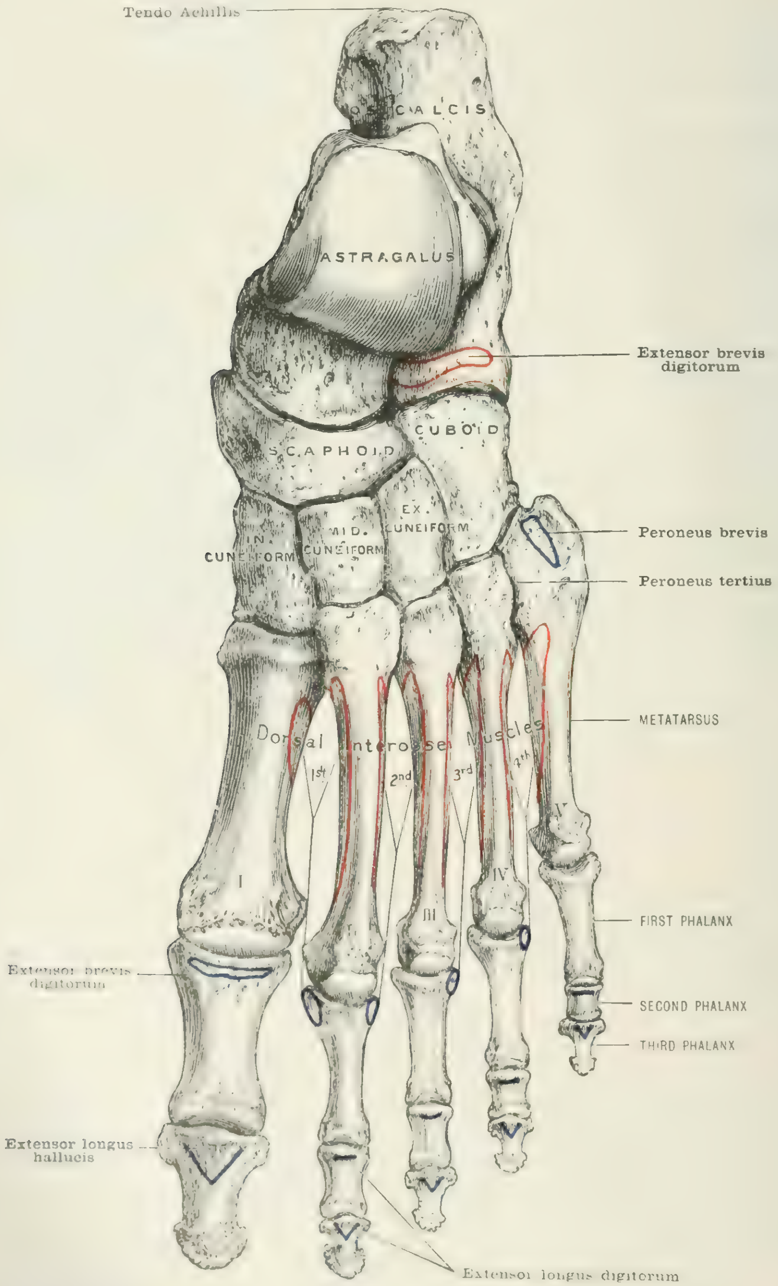
The **inferior surface** is occupied by an elongated concave facet for articulation with the calcaneum.

The **internal surface** presents a **pyriform** facet, broad in front, and continuous with the trochlea: it articulates with the tibial malleolus. Below this facet, the inner surface is rough for the attachment of the deep fibres of the deltoid ligament.

The **external surface** is almost entirely occupied by a **triangular** concave facet, broad above where it is continuous with the trochlea, for articulation with the fibular malleolus.

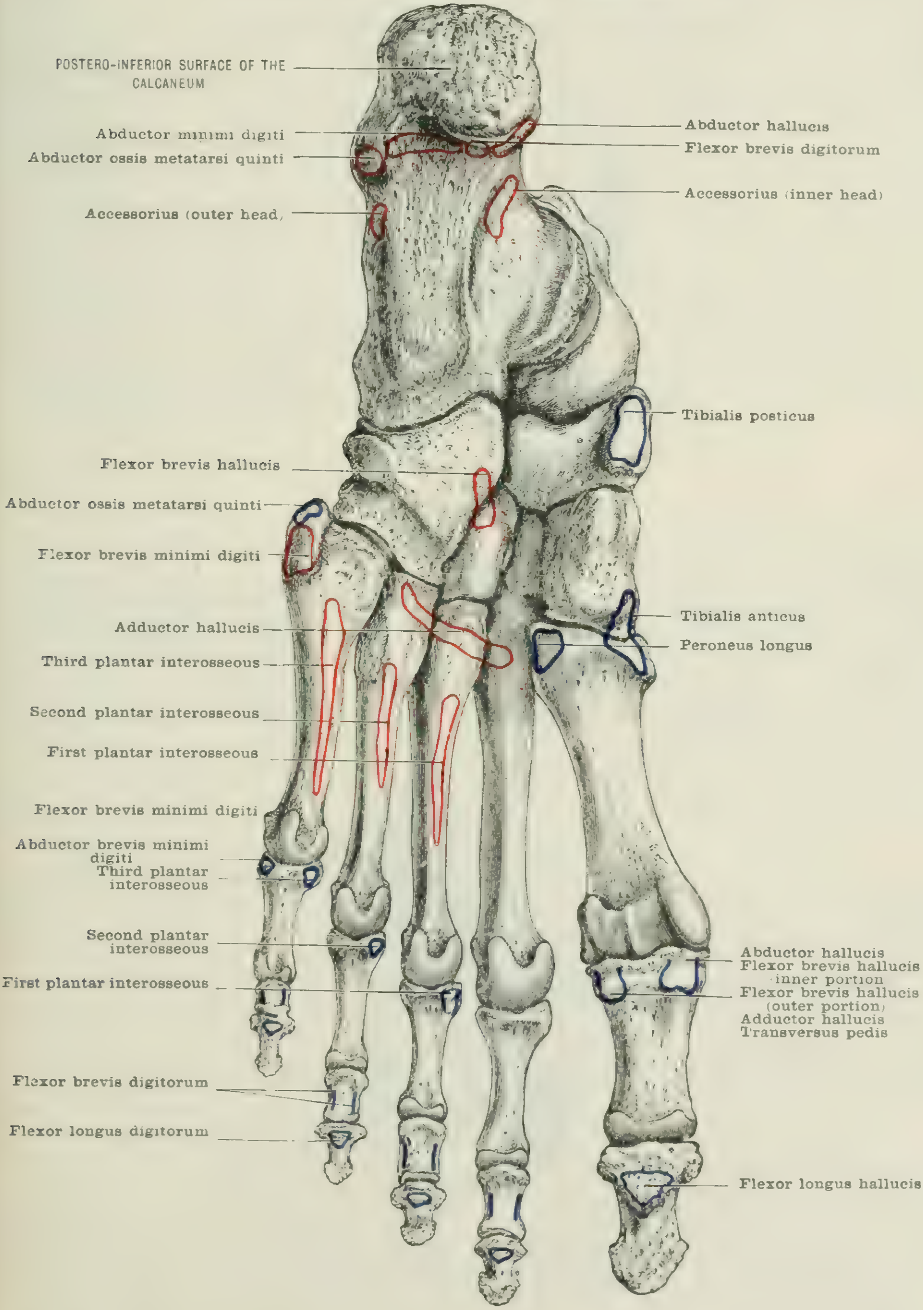
The **posterior surface** is little more than a ridge of bone traversed obliquely by a deep groove, which receives the tendon of the *flexor longus hallucis* muscle. Externally, this groove is limited by a prominent tubercle, which affords attachment to the posterior fasciculus of the external lateral ligament of the ankle.

FIG. 166.—THE LEFT FOOT. (Dorsal surface.)


Tendo Achillis
OS CALCIS
ASTRAGALUS
Extensor brevis digitorum
CUBOID
SCAPHOID
EX. CUNEIFORM
MID. CUNEIFORM
IN. CUNEIFORM
Peroneus brevis
Peroneus tertius
Dorsal Interossei Muscles
1st
2nd
3rd
4th
METATARSUS
I
III
IV
V
FIRST PHALANX
SECOND PHALANX
THIRD PHALANX
Extensor brevis digitorum
Extensor longus hallucis
Extensor longus digitorum

The **neck** is the constricted portion of the bone, and is continuous posteriorly with the body of the astragalus. Superiorly, the neck is rough, and has numerous foramina for blood-vessels. Inferiorly, it presents a deep groove, directed from behind forwards and outwards. When the astragalus is articulated with the calcaneum, this furrow is converted into a canal in which is lodged the calcaneo-astragaloid (interosseous) ligament. The inner edge of this furrow is limited by an articular facet, which runs forwards to become continuous with the facet on the head of the bone, and, like the articular surface of the sustentaculum tali of the calcaneum on which it glides, is sometimes divided.

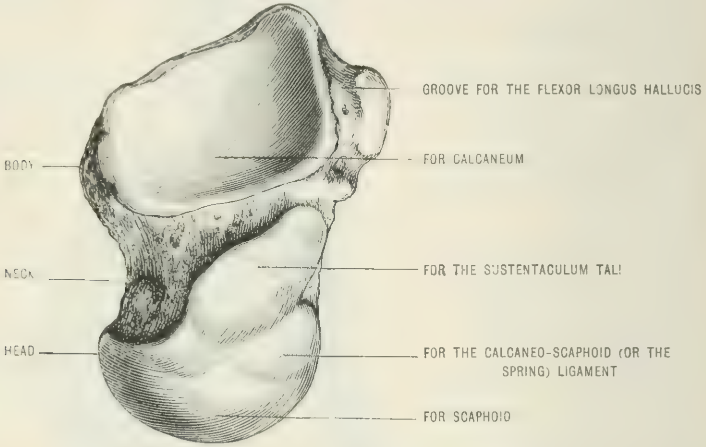
FIG. 167.—THE LEFT FOOT. (Plantar surface.)


POSTERO-INFERIOR SURFACE OF THE CALCANEUM
Abductor minimi digiti
Abductor ossis metatarsi quinti
Accessorius (outer head)
Abductor hallucis
Flexor brevis digitorum
Accessorius (inner head)
Tibialis posticus
Flexor brevis hallucis
Abductor ossis metatarsi quinti
Flexor brevis minimi digiti
Adductor hallucis
Third plantar interosseous
Second plantar interosseous
First plantar interosseous
Tibialis anticus
Peroneus longus
Flexor brevis minimi digiti
Abductor brevis minimi digiti
Third plantar interosseous
Second plantar interosseous
First plantar interosseous
Abductor hallucis
Flexor brevis hallucis (inner portion)
Flexor brevis hallucis (outer portion)
Adductor hallucis
Transversus pedis
Flexor brevis digitorum
Flexor longus digitorum
Flexor longus hallucis

The **head** of the astragalus is furnished anteriorly with an ovoid facet, which is received by the posterior surface of the scaphoid. On the inner and lower part, at the spot where the sustentacular facet becomes confluent with that on the head, there is a smaller facet separated by a ridge: this plays upon the calcaneo-scaphoid or spring ligament.

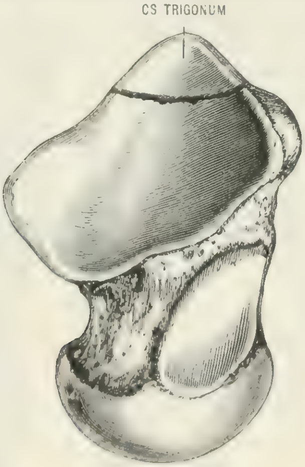
The os trigonum.—Occasionally the small portion of the astragalus posterior to the trochlear surface containing the groove which lodges the *flexor longus hallucis* tendon is separate from the rest of the astragalus, and is known as the **os trigonum**, or secondary astragalus (fig. 169).

Fig. 168.—The Left Astragalus. (Plantar view.)


GROOVE FOR THE FLEXOR LONGUS HALLUCIS
BODY
FOR CALCANEUM
NECK
FOR THE SUSTENTACULUM TALI
HEAD
FOR THE CALCANEO-SCAPHOID (OR THE SPRING) LIGAMENT
FOR SCAPHOID

Articulations.—The astragalus articulates with four bones, the tibia, fibula, scaphoid, and calcaneum; and presents seven articular facets; and when the facet for the sustentaculum tali is divided, as is so often the case, the articular surfaces are increased to eight. Sometimes it presents a facet on the outer margin of its head for the cuboid, thus increasing the articular surfaces to nine.

Fig. 169.—An Astragalus with the Os Trigonum.


OS TRIGONUM

Ligaments:—

Internal lateral ligament (deltoid).
External lateral ligament.
Astragalo-scaphoid.
Calcaneo-astragaloid (interosseous).
External calcaneo-astragaloid.
Posterior calcaneo-astragaloid.

Blood-supply.—The astragalus is supplied by the dorsalis pedis artery and its tarsal branch.

Ossification.—The astragalus is ossified from one, occasionally from two, nuclei. The principal centre for this bone appears in the middle of the cartilaginous astragalus at the seventh month of embryonic life. The additional centre is deposited in the posterior portion of the bone, and forms that part of the astragalus which, when it remains separate from the rest of the bone, is known as the **os trigonum.** At birth, the astragalus presents some important peculiarities in the disposition of the articular facet on the tibial side of its body, and in the obliquity of its neck. If, in the adult astragalus, a line be drawn through the middle of the trochlear surface parallel with its inner border, and a second line be drawn along the outer side of the neck of the bone so as to intersect the first, the angle formed by these two lines will express the obliquity of the neck of the bone. This in the adult varies greatly, but the average may be taken as 10°. In the fœtus at birth the angle averages 35°, whilst in a young orang it measures 45°. In the normal adult astragalus the articular surface on the tibial side is limited to the body of the bone. In the fœtal astragalus it extends for some distance on to the neck, and sometimes reaches almost as far forward as the scaphoid facet on the head of the bone. This disposition of the inner malleolar facet is a characteristic feature of the astragalus in the chimpanzee and the orang. It is related to the inverted position of the foot which is found in the human embryo to near the period of birth, and is of interest to the surgeon in connection with some varieties of club-foot. (Shattock and Parker.)

THE CALCANEUM

The **calcaneum,** or **os calcis,** is the largest tarsal bone. It is cuboidal in shape, and presents, for examination, six surfaces.

The **superior surface** has in its middle a large, oval, convex, articular facet for the under aspect of the body of the astragalus; behind the facet, the bone is rough and convex laterally. In front of the facet the bone presents a deep depression, the floor of which is rough for the attachment of ligaments, especially the calcaneo-astragaloid, and the origin of the *extensor brevis digitorum* muscle; when the calcaneum and astragalus are articulated, this portion of the bone forms a floor to a cavity sometimes called the **sinus pedis.** Internally, this upper surface of the bone presents a well-marked lip, the **sustentaculum tali,** furnished with an elongated concave facet, occasionally divided into two, for articulation with the neck of the astragalus.

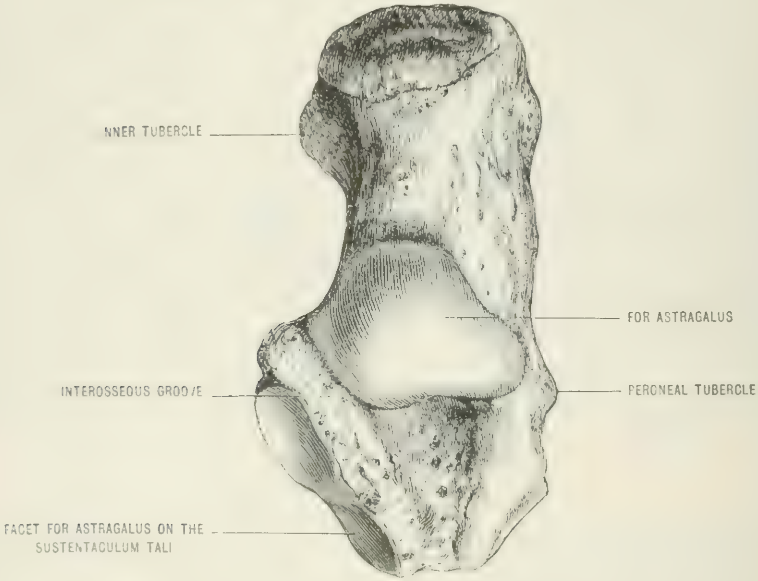
The **inferior surface** is narrow and rough; it ends posteriorly in two **tubercles**: the **inner** is the larger and broader, the **outer** is narrower but prominent. The inner tubercle affords origin to the *abductor hallucis*, the *flexor brevis digitorum*, and the *abductor minimi digiti;* the last muscle also arises from the outer tubercle, and the ridge of bone connecting the tubercles. The outer tubercle affords attachment to the *abductor ossis metatarsi quinti.* The rough surface in front of the tubercles gives attachment to the long plantar ligament (calcaneo-cuboid) and the outer head of the *flexor accessorius.* Near its anterior end this surface forms a rounded eminence, the **anterior tubercle,** from which (and the shallow groove in front) the short plantar (calcaneo-cuboid) ligament arises.

The **external surface** is rough and slightly convex. Near the middle of this surface there is a small tubercle for the middle fasciculus of the external lateral ligament of the ankle-joint. Anteriorly, we notice the two shallow **peroneal grooves,** separated by a **tubercle,** which is sometimes very prominent. The upper groove is for the tendon of the *peroneus brevis*, and the lower lodges the tendon of the *peroneus longus.*

The **inner surface** is deeply concave, the hollow being increased by the overhanging **sustentaculum tali** in front and above, and the prominent inner tubercle posteriorly. The under aspect of the sustentaculum is deeply grooved for the tendon of the *flexor longus hallucis*, whilst the hollow below receives the plantar vessels and nerves. Its lower border serves for the attachment of the inner head of the *flexor accessorius*. The margin of the sustentaculum has attached to it a part of the deltoid ligament.

The **anterior surface** is a concave articular facet for the posterior surface of the cuboid. Its outer and superior angle is somewhat prominent.

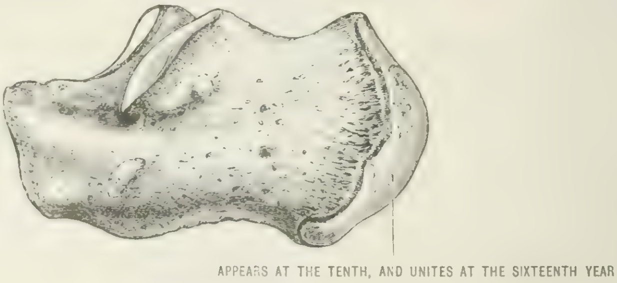
FIG. 170.—THE LEFT CALCANEUM. (Dorsal view.)


NNER TUBERCLE
FOR ASTRAGALUS
INTEROSSEOUS GROOVE
PERONEAL TUBERCLE
FACET FOR ASTRAGALUS ON THE SUSTENTACULUM TALI

The **posterior surface** is roughly rounded: the lower part gives attachment to a pad of fat: the middle part serves for the attachment of the *tendo Achillis*. At its upper part it is smooth, and is in relation with a bursa.

Articulations.—The calcaneum articulates with the cuboid, the astragalus, and with the os trigonum when it exists as a separate element.

FIG. 171.—THE CALCANEUM AT THE FIFTEENTH YEAR, SHOWING THE EPIPHYSIS.


APPEARS AT THE TENTH, AND UNITES AT THE SIXTEENTH YEAR

Muscles attached to the calcaneum:—

Extensor brevis digitorum.
Abductor hallucis.
Flexor brevis digitorum.
Abductor minimi digiti.
Abductor ossis metatarsi quinti.
Accessorius.
Tendo Achillis.
Plantaris.
And a slip from the tibialis posticus.

Ligaments:—

Internal lateral of ankle.
External lateral of ankle.
Anterior annular.
Calcaneo-astragaloid (interosseous).

Superior calcaneo-cuboid ligaments.
Inferior calcaneo-cuboid ligaments.
Internal annular.
External annular.
External calcaneo-astragaloid.
Posterior calcaneo-astragaloid.
Superior calcaneo-scaphoid.
Inferior calcaneo-scaphoid.

Blood-supply.—The calcaneum is a vascular bone, and derives its blood from the posterior tibial, and the internal and external malleolar arteries.

Ossification.—The primary nucleus for this bone is deposited in the sixth month of embryonic life. In the tenth year a nucleus appears for the epiphysis at the heel, and unites with the body of the bone at the sixteenth year. The inner and outer tubercles are formed by the epiphysis.

THE CUBOID

This bone is situated on the outer side of the tarsus; its **posterior surface** is reniform in shape and articular for the anterior face of the calcaneum. The **anterior surface** is smaller, and divided by a low vertical ridge; the inner facet is for the base of the fourth, the outer facet receives the base of the fifth metatarsal bone. The **upper** (dorsal) **surface** is rough and non-articular. The **inferior** (plantar) **surface** is divided by a prominent ridge, which limits a deep furrow directed from without forwards and inwards. This, the **peroneal groove,** lodges the tendon of the *peroneus longus.*

Fig. 172.—The Left Cuboid. (Inner view.)

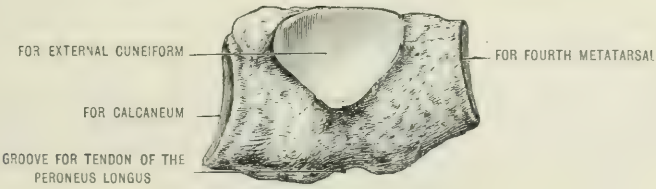

FOR EXTERNAL CUNEIFORM
FOR CALCANEUM
GROOVE FOR TENDON OF THE PERONEUS LONGUS
FOR FOURTH METATARSAL

Fig. 173.—The Left Cuboid. (Inner view.)

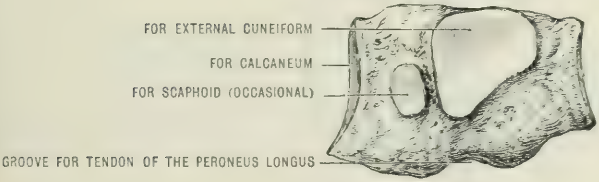
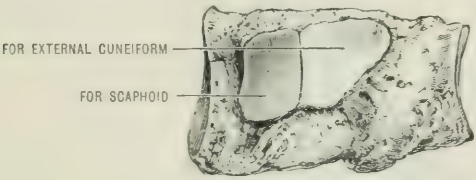

FOR EXTERNAL CUNEIFORM
FOR CALCANEUM
FOR SCAPHOID (OCCASIONAL)
GROOVE FOR TENDON OF THE PERONEUS LONGUS

Fig. 174.—The Left Cuboid. (Inner view.)


FOR EXTERNAL CUNEIFORM
FOR SCAPHOID

The corner of the ridge on the narrow **outer** (fibular) **border** of the bone is usually faceted for a sesamoid bone frequently found in the tendon of the peroneus longus. The margin of the ridge and the surface of bone behind it afford attachment to the long and short plantar (calcaneo-cuboid) ligaments. The *flexor brevis hallucis* muscle has a small attachment to this part of the cuboid.

The **internal surface** presents near its middle and upper part an oval facet for articulation with the external cuneiform bone (fig. 172): behind this, a second facet for the scaphoid is frequently seen (fig. 173). Generally the two facets are confluent and form an elliptical surface (fig. 174). The remainder of the internal surface is rough, and has strong interosseous ligaments attached to it.

Jutting from the inferior internal angle of the posterior surface is a process of bone (calcanean process of cuboid), which projects beneath the sustentaculum tali. This process occasionally terminates in a rounded facet, which plays on the head of the astragalus external to the facet for the spring ligament.

Articulations.—The cuboid articulates with the calcaneum, the external cuneiform, the fourth and fifth metatarsal bones, frequently with the scaphoid, and occasionally with the astragalus.

Muscles attached to the cuboid :—

Tibialis posticus.	Flexor brevis hallucis.

Ligaments :—

Superior calcaneo-cuboid.	Inferior calcaneo-cuboid.

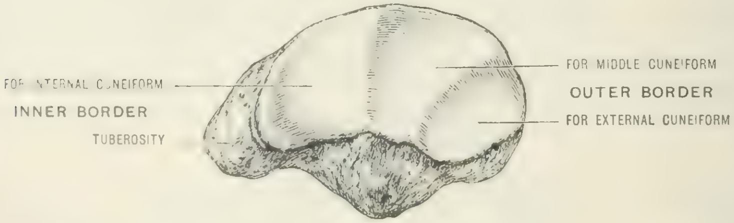
Interosseous and the cubo-scaphoid ligaments.

Ossification.—The cuboid is ossified from a single centre which appears a few weeks after birth. Occasionally the nucleus is visible as a minute earthy spot in the middle of the cartilage at birth.

THE SCAPHOID

The scaphoid (navicular) bone receives in the hollow of its **posterior surface** the head of the astragalus. **Anteriorly** it is convex, and divided by two vertical ridges into three facets, for the internal, middle, and external cuneiform bones.

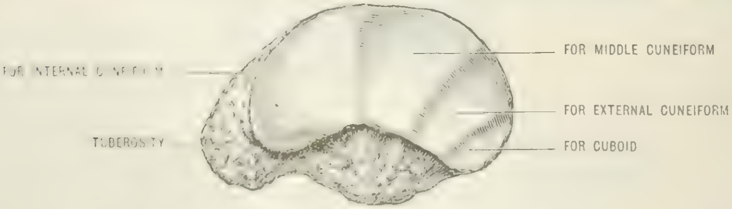
Fig. 175.—The Left Scaphoid. (Anterior view.)



Occasionally a **fourth** facet, extremely variable in size, is seen at the outer inferior angle for the cuboid.

The **upper** (dorsal) **surface** is rough and broad; the **inferior** (plantar) **surface** is nothing more than a ridge. The **outer surface** is rough for ligaments; whilst the **inner** forms a large and prominent eminence, the **scaphoid tuberosity**, which affords an important attachment for the *tibialis posticus* tendon.

Fig. 176.—The Left Scaphoid, showing a Facet for the Cuboid.



Articulations.—With the head of the astragalus, with the three cuneiform bones, and frequently with the cuboid.

Muscle attached to the scaphoid.—The tibialis posticus is inserted.

Ligaments:—

Dorsal, plantar, and interosseous cubo-scaphoid.
Dorsal and plantar scapho-cuneiform.
External and inferior calcaneo-scaphoid.
Astragalo-scaphoid.

Ossification.—The nucleus for the scaphoid appears in the course of the fourth year. The tubercle of the scaphoid, into which the *tibialis posticus* acquires its main insertion, occasionally develops separately, and sometimes remains distinct from the rest of the bone.

THE CUNEIFORM BONES

The cuneiform bones, **three** in number, are named from within outwards—**internal, middle,** and **external.** They are wedge-shaped.

The **INTERNAL CUNEIFORM** is distinguished by its large size, and from the fact that, when articulated, the **base** of the wedge is directed downwards, and the **sharp border** upwards. The **posterior surface** is concave and pyriform for articulating with the inner facet of the scaphoid. The **anterior surface** is a reniform articular facet for the base of the first metatarsal. The **internal surface** is rough, and presents an oblique groove for the tendon of the *tibialis anticus:* this groove is limited inferiorly by an oval facet into which a portion of the tendon is inserted.

FIG. 177.—THE LEFT INTERNAL CUNEIFORM. (Internal surface.)

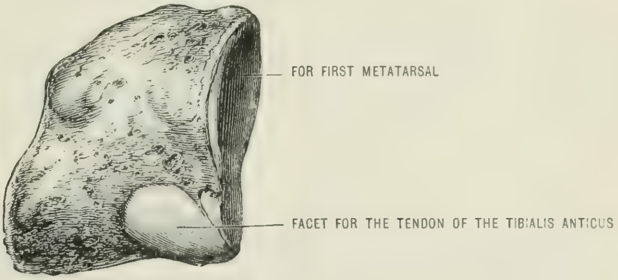
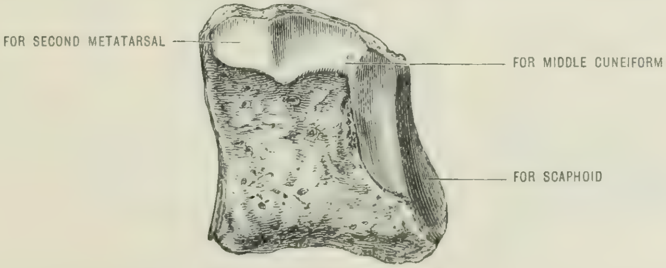


FIG. 178.—THE LEFT INTERNAL CUNEIFORM. (External surface.)



The **external surface** is concave and rough, except along the posterior and superior borders. Near the anterior extremity of the superior border there exists a distinct circular facet for the inner side of the base of the second metatarsal. In front of the facet a few fibres of the *first dorsal interosseous* muscle arise. The remaining sinuous articular facet is for the inner surface of the middle cuneiform.

Articulations.—With the scaphoid, middle cuneiform, and the first and second metatarsals.

Muscles.—Tibialis anticus and posticus, the peroneus longus, and first dorsal interosseous.

Ossification.—A single nucleus, which appears in the course of the third year.

The **MIDDLE CUNEIFORM**, the smallest of the three, has its **base** directed upwards and the **sharp border** downwards. The **posterior** concave surface is articular for the middle facet of the scaphoid. The **anterior,** somewhat narrower than the posterior surface, articulates with the base of the second metatarsal. The **internal** surface has a facet extending along its upper and posterior borders for the internal cuneiform. The **external** surface has a facet along the posterior border, and occasionally one at the anterior inferior angle for the external cuneiform.

Fig. 179.—The Left Middle Cuneiform. (Internal surface.)

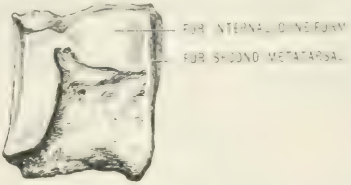
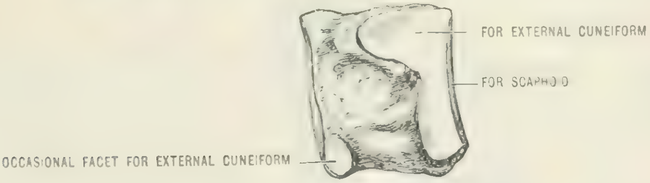

FOR INTERNAL CUNEIFORM
FOR SECOND METATARSAL

Fig. 180.—The Left Middle Cuneiform. (External surface.)

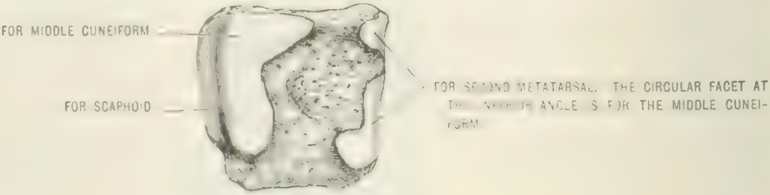

FOR EXTERNAL CUNEIFORM
FOR SCAPHOID
OCCASIONAL FACET FOR EXTERNAL CUNEIFORM

Articulations.—With the internal and external cuneiform bones, the scaphoid and the second metatarsal.

Ossification.—A single nucleus appears in the fourth year.

The **EXTERNAL CUNEIFORM** has its **base** directed upwards, and its **narrow border** downwards. The **posterior surface** is faceted for the scaphoid; and the **anterior,** triangular in shape articulates with the base of the third metatarsal. The **internal surface** has a large facet, extending along the posterior border, for the middle cuneiform; and on the anterior border, a narrow irregular facet for the outer border of the base of the second metatarsal; and occasionally a small facet at the anterior inferior angle for the middle cuneiform. The **outer surface** has a broad distinctive facet, near its posterior superior angle, for the cuboid; and at the anterior superior angle there is usually a facet for the inner side of the base of the fourth metatarsal.

Fig. 181.—The Left External Cuneiform. (Internal surface.)

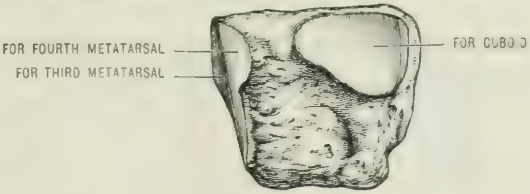

FOR MIDDLE CUNEIFORM
FOR SCAPHOID
FOR SECOND METATARSAL. THE CIRCULAR FACET AT THE INFERIOR ANGLE IS FOR THE MIDDLE CUNEIFORM

Articulations.—With the middle cuneiform, the scaphoid, the cuboid, and the second, third, and fourth metatarsals.

Muscles.—The flexor brevis hallucis and a slip from the tibialis posticus.

Ossification.—A single nucleus appears in the course of the first year.

Fig. 182.—The Left External Cuneiform. (External surface.)

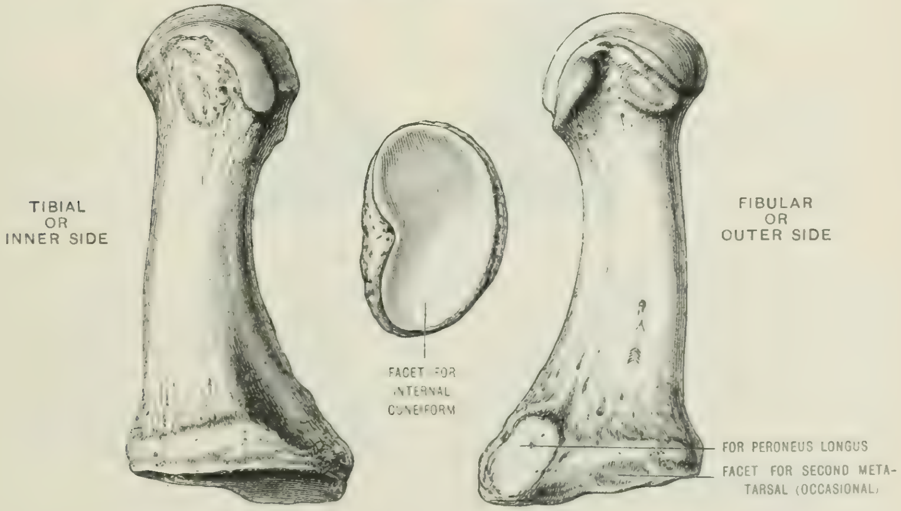

FOR FOURTH METATARSAL
FOR THIRD METATARSAL
FOR CUBOID
3

The three cuneiform bones rest posteriorly against the scaphoid; and as they are of unequal length, the middle being the smallest, it follows that when the bones are placed in their natural positions a deep gap or recess is formed in front. Into this recess the base of the second metatarsal is received, thus explaining the small facets at the anterior superior angles of the internal and external cuneiforms.

THE METATARSUS

The **metatarsus** consists of five bones, numbered one to five, beginning at the hallux. Each metatarsal presents a proximal portion termed the base, and a distal end or **head.** The shaft of each bone, with the exception of the first, is prismatic; the base of the prism is directed upwards, and the narrow edge downwards. The shaft tapers gradually from the base to the head and is slightly bowed, the concavity being on the plantar aspect.

Fig. 183.—The First (Left) Metatarsal.


TIBIAL OR INNER SIDE
FACET FOR INTERNAL CUNEIFORM
FIBULAR OR OUTER SIDE
FOR PERONEUS LONGUS
FACET FOR SECOND METATARSAL (OCCASIONAL)

The **base** is prismatic: its terminal surface is faceted for articulation with the tarsus, and the adjacent borders of the base present small facets, in most cases for adjacent metatarsals.

The **head** is semicircular, forming a convex articular surface for the base of the first phalanx. The compressed sides of the head present near their centres a depression surmounted by a prominent tubercle. The plantar surface is deeply grooved for the passage of flexor tendons. To the sides of the head the lateral ligaments of the metatarso-phalangeal joints are attached.

The **FIRST METATARSAL** is the most modified: it is shorter, but much thicker than its fellows. The **base** presents a reniform, slightly concave facet for the internal cuneiform bone. On the outer (fibular) side of the base, near its lower angle, there is a tubercle into which the *peroneus longus* is inserted. A little above this, there is frequently a shallow but easily recognised facet where it comes into contact with the base of the second metatarsal.

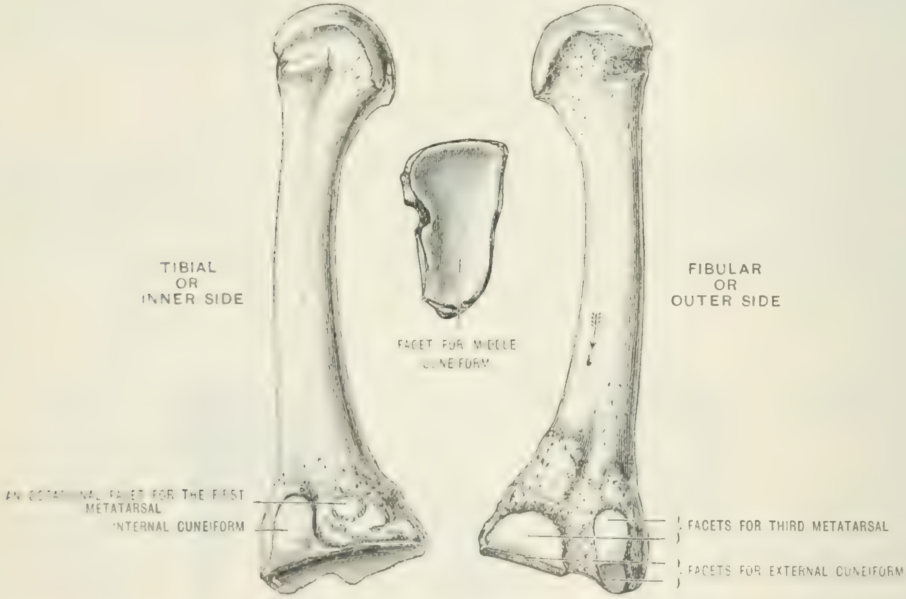
The **head** of the bone has two deep grooves on the plantar surface for the sesamoids developed in the *flexor brevis hallucis* muscle.

Muscles.—Peroneus longus; tibialis anticus; first dorsal interosseous.

Blood-supply.—The nutrient vessel enters the shaft on the fibular side, and is directed towards the head of the bone.

The **SECOND METATARSAL** is the longest of the series. Its **base** is prolonged backwards to occupy the space between the internal and external cuneiform bones; this leads to the formation of a small facet at the superior angle on the tibial side where it articulates with the internal cuneiform. It occasionally presents a small facet for the first metatarsal. The **outer** (fibular) **side** of the base has two facets, each subdivided in well-marked bones. The dorsal facet is long and narrow; the posterior section articulates with the external cuneiform; the anterior is for the third metatarsal. The lower facet is somewhat circular: its posterior section is for the external cuneiform, the anterior for the third metatarsal. The terminal facet on the base is for the middle cuneiform: thus the **second metatarsal articulates with three cuneiform bones.**

FIG. 184.—THE SECOND (LEFT) METATARSAL.


TIBIAL
OR
INNER SIDE
FIBULAR
OR
OUTER SIDE
FACET FOR MIDDLE CUNEIFORM
AN OCCASIONAL FACET FOR THE FIRST METATARSAL
INTERNAL CUNEIFORM
FACETS FOR THIRD METATARSAL
FACETS FOR EXTERNAL CUNEIFORM

Muscles.—Adductor hallucis; first and second dorsal interosseous.

Blood-supply.—The nutrient artery enters on the fibular side near the middle of the shaft, and is directed towards the base of the bone.

The **THIRD METATARSAL** articulates by its **base** with the external cuneiform. It has on the **inner** (tibial) **side** two facets: one below the other for the second metatarsal, and a large facet on the fibular side for the fourth metatarsal.

Muscles.—Adductor hallucis; first plantar; second and third dorsal interosseous.

Blood-supply.—The nutrient artery enters on the inner (tibial) side of the shaft near its middle: it is directed towards the base.

The **FOURTH METATARSAL** has a somewhat quadrilateral terminal facet for the cuboid bone. On its **inner** (tibial) **side** it has a large facet for the third metatarsal: the posterior part of this is occasionally marked off for the external cuneiform, but this is far from constant. When this cuneiform facet is present, the facet extends to the base of the bone. When absent, the surface is rough for ligaments. The **outer** (fibular) **side** has a single facet for the fifth metatarsal.

Fig. 185.—The Third (Left) Metatarsal.

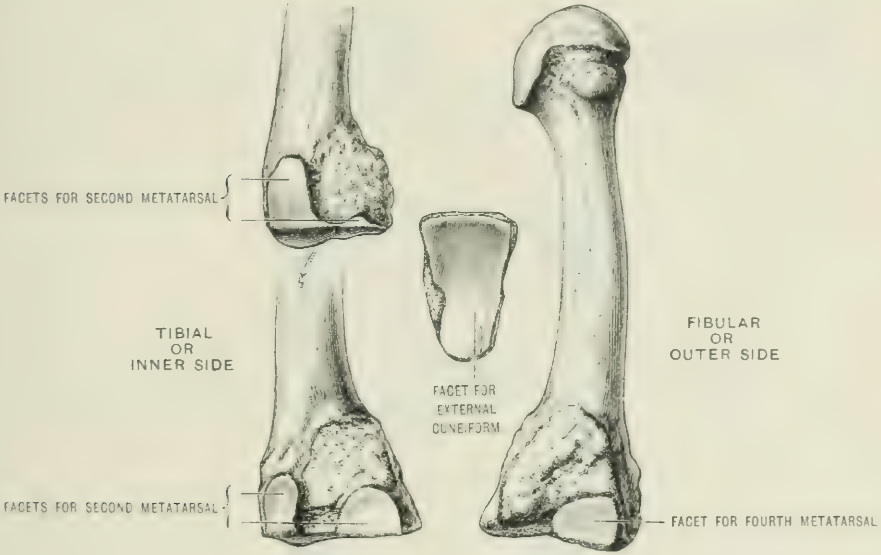
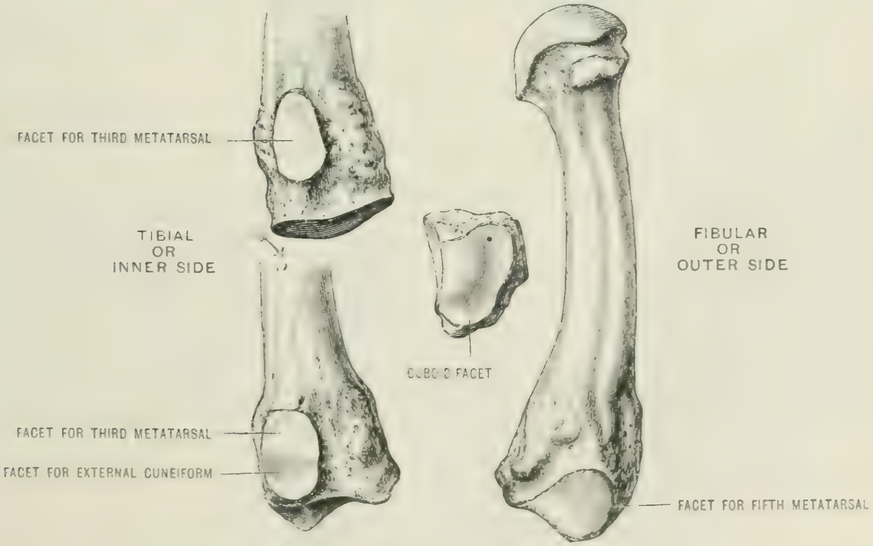

FACETS FOR SECOND METATARSAL
TIBIAL OR INNER SIDE
FACET FOR EXTERNAL CUNEIFORM
FIBULAR OR OUTER SIDE
FACETS FOR SECOND METATARSAL
FACET FOR FOURTH METATARSAL

Fig. 186.—The Fourth (Left) Metatarsal.


FACET FOR THIRD METATARSAL
TIBIAL OR INNER SIDE
FIBULAR OR OUTER SIDE
CUBOID FACET
FACET FOR THIRD METATARSAL
FACET FOR EXTERNAL CUNEIFORM
FACET FOR FIFTH METATARSAL

Muscles.—Adductor hallucis; second plantar interosseous; third and fourth dorsal interosseous.

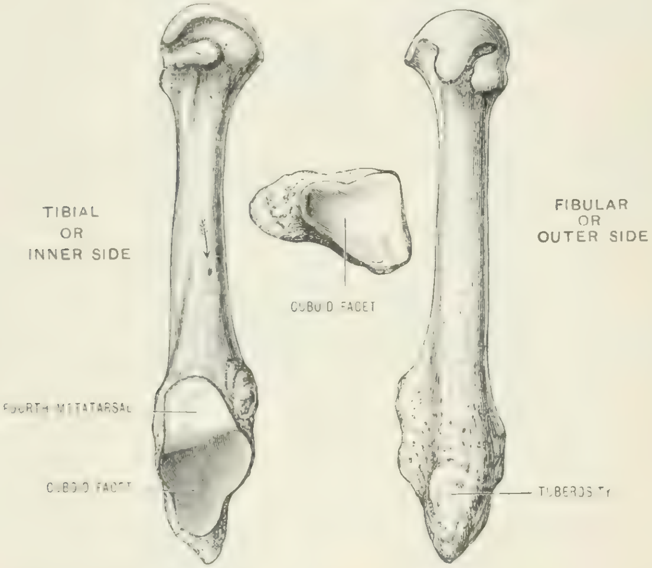
Blood-supply.—The nutrient artery of the shaft enters on the inner (tibial) side and runs towards the base.

The **FIFTH METATARSAL** has on the fibular side of its **base** a large nipple-shaped **tuberosity**, to which the tendon of the *peroneus brevis* is inserted. Its oblique terminal facet articulates with the cuboid, and on the tibial side it has a large facet for the fourth metatarsal. The plantar aspect of the base has a shallow groove which lodges the *abductor minimi digiti*.

Muscles :—

Third plantar interosseous.
Fourth dorsal interosseous.
Peroneus brevis.
Peroneus tertius.
Abductor ossis metatarsi quinti.
Flexor brevis minimi digiti.

Fig. 187.—The Fifth (Left) Metatarsal.



Blood-supply.—The nutrient artery enters on the tibial side of the shaft and runs towards the base.

Ossification.—Each metatarsal ossifies from two centres. The primary nucleus for the diaphysis appears in the eighth week of embryonic life in the middle of the cartilaginous metatarsal. At birth, each extremity is represented by cartilage, and that at the proximal end is ossified by extension from the primary nucleus, except in the case of the first metatarsal. For this, a nucleus appears in the third year.

The distal ends of the four outer metatarsals are ossified by secondary nuclei which make their appearance about the third year. Very frequently an epiphysis is found at the distal end of the first metatarsal as well as at its base. The shafts and epiphyses consolidate at the twentieth year. The sesamoids belonging to the *flexor brevis hallucis* begin to ossify about the fifth year.

THE PHALANGES

There are **fourteen phalanges** to each foot. The hallux has two, and the remaining toes three each. They are usually distinguished as first, second, and third. The last are sometimes called the ungual phalanges, because they support the nail.

The phalanges of the **first row** have narrow laterally compressed shafts, rounded on the dorsal and concave on the plantar aspects. The base of each has a deep

Fig. 188.—The Phalanges of the Middle Toe.

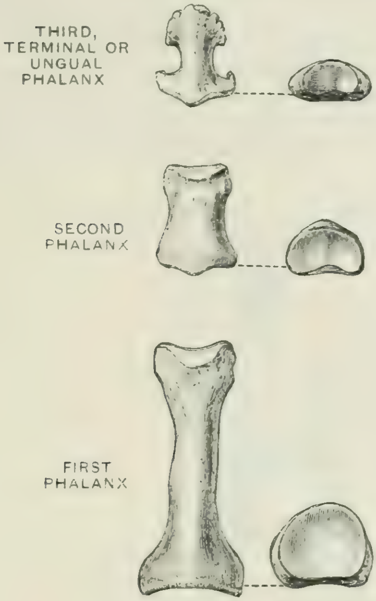
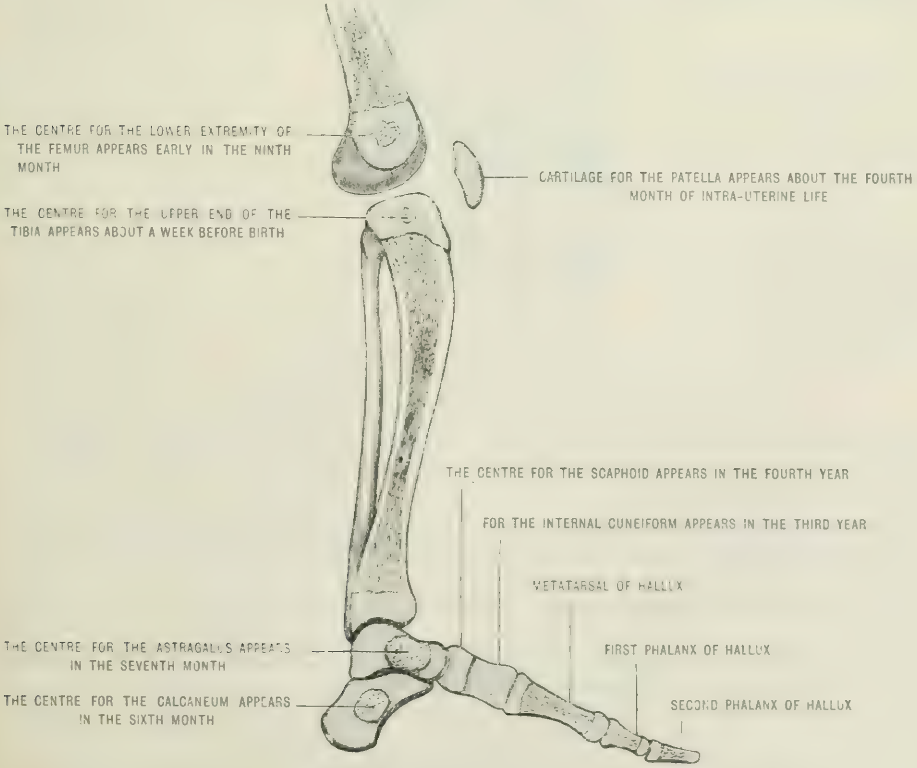

THIRD, TERMINAL OR UNGUAL PHALANX
SECOND PHALANX
FIRST PHALANX

Fig. 189.—A Longitudinal Section of the Bones of the Lower Limb at Birth.

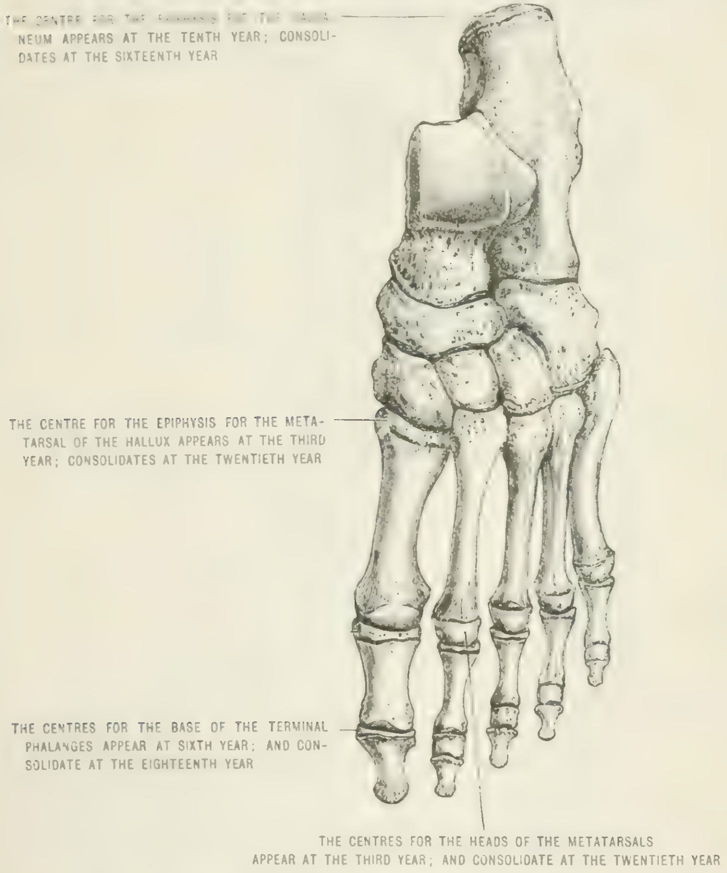

THE CENTRE FOR THE LOWER EXTREMITY OF THE FEMUR APPEARS EARLY IN THE NINTH MONTH
CARTILAGE FOR THE PATELLA APPEARS ABOUT THE FOURTH MONTH OF INTRA-UTERINE LIFE
THE CENTRE FOR THE UPPER END OF THE TIBIA APPEARS ABOUT A WEEK BEFORE BIRTH
THE CENTRE FOR THE SCAPHOID APPEARS IN THE FOURTH YEAR
FOR THE INTERNAL CUNEIFORM APPEARS IN THE THIRD YEAR
METATARSAL OF HALLUX
THE CENTRE FOR THE ASTRAGALUS APPEARS IN THE SEVENTH MONTH
FIRST PHALANX OF HALLUX
THE CENTRE FOR THE CALCANEUM APPEARS IN THE SIXTH MONTH
SECOND PHALANX OF HALLUX

glenoid fossa for the convex head of the corresponding metatarsal, whilst the head has a trochlear surface for the second phalanx.

The phalanges of the **second row** are stunted, insignificant bones. Their shafts are flatter than those of the first row, besides being much shorter. The **bases** have two depressions, separated by a vertical ridge. The heads present **trochlear** surfaces for the ungual phalanges.

The **third, terminal,** or **ungual** phalanges are easily recognised. The bases articulate with the second phalanges; the shafts are expanded to support the nails, and their plantar surfaces are rough where they come into relation with the pulp of the digit.

Fig. 190.—The Secondary Ossific Centres of the Foot.


THE CENTRE FOR THE EPIPHYSIS FOR THE CALCANEUM APPEARS AT THE TENTH YEAR; CONSOLIDATES AT THE SIXTEENTH YEAR
THE CENTRE FOR THE EPIPHYSIS FOR THE METATARSAL OF THE HALLUX APPEARS AT THE THIRD YEAR; CONSOLIDATES AT THE TWENTIETH YEAR
THE CENTRES FOR THE BASE OF THE TERMINAL PHALANGES APPEAR AT SIXTH YEAR; AND CONSOLIDATE AT THE EIGHTEENTH YEAR
THE CENTRES FOR THE HEADS OF THE METATARSALS APPEAR AT THE THIRD YEAR; AND CONSOLIDATE AT THE TWENTIETH YEAR

The **first phalanx of the hallux** gives insertion to the following muscles:—Flexor brevis hallucis; abductor hallucis; transversus pedis; adductor hallucis; extensor brevis digitorum.

The **first phalanx of second toe**: The first and second dorsal interosseous.

The **first phalanx of third toe**: Third dorsal interosseous; first plantar interosseous.

The **first phalanx of fourth toe**: Second plantar interosseous; fourth dorsal interosseous.

The **first phalanx of fifth toe**: Third plantar interosseous; flexor brevis minimi digiti; and abductor minimi digiti.

The **second phalanx of hallux**: Flexor longus hallucis; extensor proprius hallucis.

The **second phalanges of the remaining toes**: Extensor longus digitorum; flexor brevis digitorum.

The **third phalanges**: Flexor longus digitorum; extensor longus digitorum.

Ossification.—Like the phalanges of the fingers, those of the toes ossify from a primary and a secondary nucleus. The centres for the shaft appear during the eighth and tenth weeks of embryonic life; the secondary centres appear as thin scale-like epiphyses at the proximal ends between the fourth and eighth years. They consolidate earlier than the corresponding epiphyses in the fingers.

The ungual phalanges, like those of the fingers, ossify from the distal extremity.

The average dates of ossification of the bones of the foot:—

Calcaneum	Sixth month.
Epiphysis	Tenth year.
Astragalus	Seventh month.
Cuboid	At, or near, the ninth month.
Scaphoid	Fourth or fifth year.
Internal cuneiform	Third year.
Middle cuneiform	Fourth year.
External cuneiform	First year.
Metatarsals	Eighth to ninth week.
Epiphyses	Third year; consolidate at the twentieth year.
Phalanges	Eighth to tenth week.
Epiphyses	Fourth to eighth year; consolidate about the eighteenth year.

SECTION II

THE ARTICULATIONS

By HENRY MORRIS, M.A., M.B., Lond.: F.R.C.S.Eng.

SENIOR SURGEON TO AND LATE LECTURER ON SURGERY (FORMERLY LECTURER ON ANATOMY) AT THE MIDDLESEX HOSPITAL; MEMBER OF THE COUNCIL AND OF THE COURT OF EXAMINERS OF THE ROYAL COLLEGE OF SURGEONS, ENGLAND; EXAMINER IN SURGERY IN THE UNIVERSITY OF LONDON

THE section devoted to the Articulations or Joints deals with the union of the various and dissimilar parts of the human skeleton. The following structures enter into the formation of joints.

Bones constitute the basis of most joints. The articular ends are expanded, and are composed of cancellous tissue, surrounded by a dense and strong shell of compact tissue. This shell has no Haversian canals (the vessels of the cancellous tissue turn back and do not perforate it), or large lacunæ, and no canaliculi, and is thus well adapted to bear pressure. The long bones articulate by their ends, the flat by their edges, and the short at various parts on their surfaces.

The **Cartilage** which covers the articular ends of the bones is called **articular,** and is of the **hyaline variety.** It is firmly implanted on the bone by one surface, while the other is smooth, polished, and free, thus reducing friction to a minimum, while its slight elasticity tends to break jars. It ends abruptly at the edge of the articulation, and is thickest over the areas of greatest pressure.

Another form of cartilage, the **white fibrous,** is also found in joints:—

(i) As **interarticular cartilage** in diarthrodial joints—viz., the knee, temporo-mandibular, sterno-clavicular, radio-carpal, and occasionally in the acromio-clavicular. It is interposed between the ends of the bones, partially or completely dividing the synovial cavity into two. It serves to adjust dissimilar bony surfaces, adding to the security of, while it increases the extent of motion at, the joint; it also acts as a buffer to break shocks.

(ii) As **circumferential** or marginal fibro-cartilages, which serve to deepen the sockets for the reception of the heads of bones—e.g. the glenoid and cotyloid ligaments of the shoulder and hip. Another form of marginal plate is seen in the glenoid ligaments of the fingers and toes, which deepen the articulations of the phalanges and add to their security.

(iii) As **connecting fibro-cartilage.** The more pliant and elastic is the more cellular form, and is found in the intervertebral discs; while the less yielding and more fibrous form is seen in the sacro-iliac and pubic articulations, where there is little or no movement.

The **Ligaments** which bind the bones together are strong bands of white fibrous tissue, forming a more or less perfect capsule, round the articulation. They are pliant but inextensile, varying in shape, strength, and thickness according to the kind of articulation into which they enter. They are closely connected with the periosteum of the bones they unite. In some cases—as the ligamenta subflava which unite parts not in contact—they are formed of yellow elastic tissue.

The **synovial membrane** lines the interior of the fibrous ligaments, thus excluding them, as well as the cushions or pads of fatty tissue situate within and the tendons which perforate the fibrous capsule, from the articular cavity. It is a thin delicate membrane, frequently forming folds and fringes which project into the cavity of the joint; or, as in the knee, stretches across the cavity, forming a so-called synovial ligament. In these folds are often found pads of fatty tissue, which fill up interstices, and form soft cushions between the contiguous bones. Sometimes these fringes become villous and pedunculated, and cause pain on movement of the joints. They contain fibro-fatty tissue, with an isolated cartilage cell or two. The synovial membrane is well supplied with blood, especially near the margins of the articular cartilages and in the fringes. It secretes a thick glairy fluid like white of egg, called synovia, which lubricates the joint. Another variety of synovial membrane is seen in the bursæ, which are interposed between various moving surfaces. In some instances bursæ in the neighbourhood of a joint may communicate with the synovial cavity of that joint.

THE VARIOUS KINDS OF ARTICULATIONS

There are three chief varieties of joints—viz., synarthrodial, or immovable; amphiarthrodial, or yielding; and diarthrodial, or movable joints.

Synarthrosis is the term applied to all immovable joints in which the apposed surfaces or edges of the bones are in direct contact, as in the face bones, except the mandible, and all those of the skull; or where bone and cartilage are in immediate union, as in the case of the first rib and the sternum, and the costal cartilages and the ribs. The unions of the bones of the skull and face are usually called sutures, of which there are three chief varieties—

(1) **True sutures,** where the edges of bones are firmly implanted into one another by means of projecting processes, as in the sagittal, lambdoid, and coronal sutures.

(2) **False sutures,** where the rough edges of the bones are in simple contact without interlocking, as in the intermaxillary suture; or where they overlap one another, as in the squamous suture.

(3) **Grooved sutures,** where the edge or plate of one bone is received into a corresponding groove in the other, as in the rostrum of the sphenoid and vomer, or vomer and palatine processes of the maxillæ, and the horizontal plates of the palate bones.

Amphiarthrosis is the term applied to mixed joints which permit of slight movements, the opposed bony surfaces being firmly united by a plate or disc of fibro-cartilage. There is sometimes a partial synovial membrane. Examples are seen in the spine, sacro-iliac, and pubic joints.

Diarthrosis is the term applied to all movable joints in which the bones have smooth cartilage-covered surfaces, lubricated by synovia, and bound together by more or less perfect capsules. This class is subdivided into the following varieties:—

1. Enarthrosis, or ball-and-socket joint, where the more or less spherical head of one bone is adjusted to a socket on the other, as in the hip- and shoulder-joints. They are the most movable of all articulations, combining angular movements in all directions with axial rotation.

2. Condylarthrosis, or an articulation having on one bone an elongated surface called "condyle" and on the other a glenoid surface. They permit all the movements of a ball-and-socket joint except axial rotation.

3. Ginglymus, trochlearthrosis, or hinge-joint, where there is a pulley or trochlea on one bone and a surface adapted for moving round it on the other. The movement is principally in two directions, namely, flexion and extension, though some slight amount of lateral movement is also permitted. The most perfect

examples of this form of joint are the elbow and ankle. The knee is a much less perfect instance.

4. Trochoides, or wheel-like joints, where one bone rotates upon another. This name is given to an articulation in which either a pivot revolves in a ring, as in the superior radio-ulnar; or the ring revolves about a pivot, as in the atlanto-odontoid, and in a much less perfect form in the inferior radio-ulnar joint. Rotation is the only movement.

5. Arthrodia, a more or less simple gliding joint formed by the apposition of two plane, or nearly plane, or concavo-convex surfaces. The amount of movement is very variable in the different joints. Whilst in some, as the intermetacarpal, it is so slight that the joints have, by some writers, been described as amphiarthrosis, others are capable of all the movements of a ball-and-socket joint except rotation.

The articular processes of the vertebræ and the carpal and tarsal joints are good examples of the ordinary arthrodia, but under this head are also included the "saddle-shaped" articulations, such as the sterno-costo-clavicular and the carpo-metacarpal of the thumb, which permit the four angular movements and circumduction, but not rotation.

Table of the Various Classes of Joints

Class.	*Examples.*
I. **Synarthrosis**	
(*a*) True sutures	Lambdoid, sagittal, coronal.
(*b*) False sutures	Internasal. Intermaxillary. Costo-chondral.
(*c*) Grooved sutures	Vomer and rostrum of sphenoid.
II. **Amphiarthrosis**	Bodies of vertebræ. Symphysis pubis, sacro-iliac, sacro-coccygeal.
III. **Diarthrosis**	
(*a*) Enarthrosis	Shoulder. Hip. Astragalo-scaphoid.
(*b*) Condylarthrosis	Temporo-mandibular. Occipito-atlantal. Radio-carpal. Metacarpo-phalangeal. Metatarso-phalangeal.
(*c*) Ginglymus or Trochlearthrosis	Elbow. Ankle. Knee. Interphalangeal of fingers and toes.
(*d*) Trochoides or Lateral Ginglymus	Atlanto-odontoid. Superior Radio-ulnar. Inferior Radio-ulnar.
(*e*) Arthrodia:	
(1) Simple	Lateral atlanto-axoidean. The joints between the articular processes of the vertebræ, costo-transverse and interchondral. Acromio-clavicular. Carpal. Carpo-metacarpal of four fingers. Intermetacarpal. Tarsal. Tarso-metatarsal. Intermetatarsal. Calcaneo-astragaloid. Superior and inferior tibio-fibular.
(2) Saddle-shaped	Sterno-costo-clavicular. Carpo-metacarpal of thumb. Calcaneo-cuboid.

THE VARIOUS MOVEMENTS OF JOINTS

The movements which may take place at a joint are either gliding, angular, rotatory, or circumductory.

The **gliding** motion is the simplest, and is common to all diarthrodial joints: it consists of a simple sliding of the apposed surfaces of the bones upon one another, without angular or rotatory motion. It is the only kind of motion permitted in the carpal and tarsal joints, and in those between the articular processes of the vertebræ.

The **angular** motion is more elaborate, and increases or diminishes the angle between different parts. There are four varieties, viz.: *flexion* and *extension*, which bend or straighten the various joints, and take place in a forward and backward direction (in a perfect hinge-joint this is the only motion permitted); and *adduction* and *abduction*, which, except in the case of the fingers and toes, signifies an approach to, or deviation from, the centre line of the body. In the case of the hand, the line to or from which adduction and abduction are made is drawn through the middle finger, while in the foot it is through the second toe.

Rotation is the revolution of a bone about its own axis without much change of position. It is only seen in enarthrodial and trochoidal joints. The knee also permits of slight rotation in certain positions, which is a distinctive feature of this articulation.

Circumduction is the movement compounded of the four angular movements in quick succession, by which the moving bone describes a cone, the proximal end of the bone forming the apex, while the distal end describes the base of the cone. It is seen in the hip and shoulder, as well as in the carpo-metacarpal joint of the thumb, which thus approximates to the ball-and-socket joint.

In some situations where a variety of motion is required, strength, security, and celerity are obtained by the combination of two or more joints, each allowing a different class of action, as in the case of the wrist, the ankle, and the head with the spine. Many of the long muscles, which pass over two or more joints, act on all, so tending to co-ordinate their movements and enabling them to be produced with the least expenditure of power. Muscles also act as elastic ligaments to the joints; and when acting as such, are diffusers and combiners, not producers of movement; the short muscles producing the movement, the long diffusing it, and thus allowing the short muscles to act on more than one joint.

Muscles are so disposed at their attachments near the joints as never to strain the ligaments by tending to pull the bones apart, but, on the contrary, they add to the security of the joint by bracing the bones firmly together during their action.

The articulations may be divided for convenience of description into those: 1. of the SKULL; 2. of the TRUNK; 3. of the UPPER LIMB; and 4. of the LOWER LIMB.

1. *THE ARTICULATIONS OF THE SKULL*

The articulations of the skull comprise (1) the temporo-mandibular; and (2) those between the skull and the spinal column, namely (*a*) between the occiput and atlas; (*b*) between the atlas and axis; and (*c*) the ligaments which connect the occiput and axis.

The union of the atlas and axis is described in this section because, *firstly*, there is often a direct communication between the synovial cavity of the transverse axoidean and the occipito-atlantal joints; *secondly*, the rotatory movements of the head take place around the odontoid process; and, *thirdly*, important ligaments from the odontoid process pass over the atlas to the occiput.

(1) THE TEMPORO-MANDIBULAR ARTICULATION

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

The parts entering into the formation of this joint are:—the anterior portion of the glenoid fossa and glenoid ridge (eminentia articularis) of the temporal bone above, and the condyle of the lower jaw below. Both are covered with articular cartilage, which extends over the front of the glenoid ridge to facilitate the play of the interarticular cartilage. The ligaments which unite the bones are:—

1. Capsular.
2. Interarticular fibro-cartilage.
3. Spheno-mandibular.
4. Stylo-mandibular.

The **capsular ligament** is often described as consisting of four portions, which are, however, continuous with one another around the articulation.

1. The **anterior portion** consists of a few stray fibres connected with the anterior margin of the fibro-cartilage, and attached below to the anterior edge of the condyle, and above to the front of the glenoid ridge. Some fibres of insertion of the *external pterygoid* pass between them to be inserted into the margin of the fibro-cartilage.

2. The **posterior portion** is attached above, just in front of the Glaserian fissure, and is inserted into the back of the jaw just below its neck.

3. The **external portion** or **external lateral ligament** (fig. 191) is the strongest part of the capsule. It is broader above, where it is attached to the lower edge of the zygoma in nearly its whole length, as well as to the tubercle at the point where the two roots of the zygoma meet. It is inclined downwards and backwards, to be inserted into the outer side of the neck of the condyle. Its fibres diminish in obliquity and strength from before backwards, those coming from the tubercle being short and nearly vertical.

4. The **internal portion** or **short internal lateral ligament** (fig. 192) consists of well-defined fibres, having a broad attachment, above to the outer side of the alar spine of the sphenoid and inner edge of the glenoid fossa; and below, a narrow insertion to the inner side of the neck of the condyle. Fatty and cellular tissue separate it from the spheno-mandibular ligament which is internal to it.

The **interarticular cartilage** (fig. 193) is an oval plate interposed between and adapted to the two articular surfaces. It is thinner at the centre than at the circumference, and is thicker behind where it covers the thin bone at the bottom of the glenoid fossa which separates it from the dura mater, than in front where it covers the glenoid ridge. Its inferior surface is concave and fits on to the condyle of the lower jaw; while its superior surface is concavo-convex from before backwards, and is in contact with the articular surface of the temporal bone. It divides the joint into two separate synovial cavities, but is occasionally perforated in the centre, and thus allows them to communicate. It is connected with the capsular ligament at its circumference, and has some fibres of the *external pterygoid* muscle inserted into its anterior margin.

There are usually **two synovial membranes** (fig. 193), the superior being the larger and looser, passing down from the margin of the articular surface above, to the upper surface of the interarticular cartilage below; the lower and smaller one passes from the interarticular cartilage above to the condyle of the jaw below, extending somewhat further down behind than in front. When the interarticular cartilage is perforated, the two sacs communicate.

The **spheno-mandibular ligament** (long internal lateral) (fig. 192) is a thin, loose band, situated some little distance from the joint. It is attached above to the alar spine of the sphenoid and contiguous part of the temporal bone, and is inserted into the mandibular spine of the lower jaw. It covers the upper end of the mylo-hyoid groove, and is here pierced by the *mylo-hyoid* nerve. Its origin is a little internal to, and immediately behind, the origin of the short internal lateral ligament. It is separated from the joint and ramus of the jaw by the *external pterygoid* muscle, *internal maxillary* artery and vein, the *mandibular* nerve and artery, and the *middle meningeal* artery. It is really the fibrous remnant of a part of the mandibular (Meckelian) bar.

The **stylo-mandibular ligament** (stylo-maxillary) (figs. 191 and 192) is a process of the deep cervical fascia extending from near the tip of the styloid process to the angle and posterior border of the ramus of the jaw, between the *masseter* and *internal pterygoid* muscles. It separates the parotid from the submaxillary gland, and gives origin to some fibres of the *stylo-glossus* muscle.

FIG. 191.—EXTERNAL VIEW OF TEMPORO-MANDIBULAR JOINT.

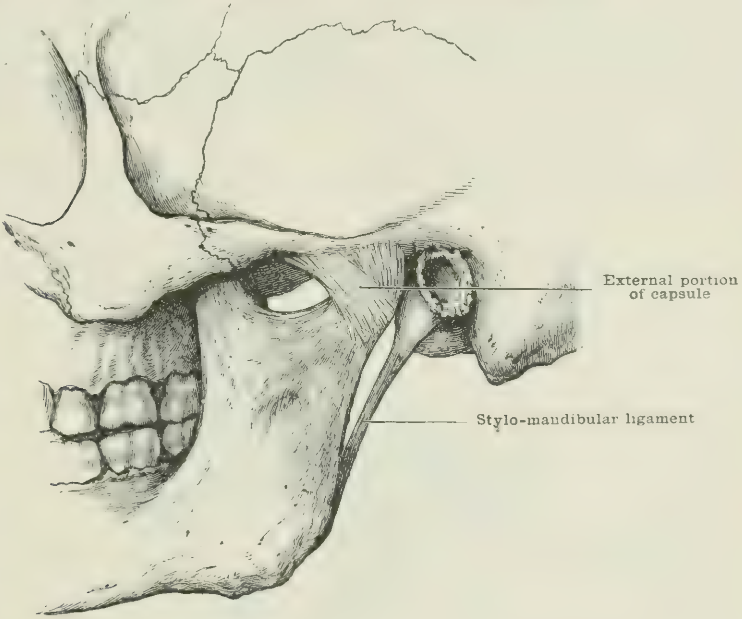
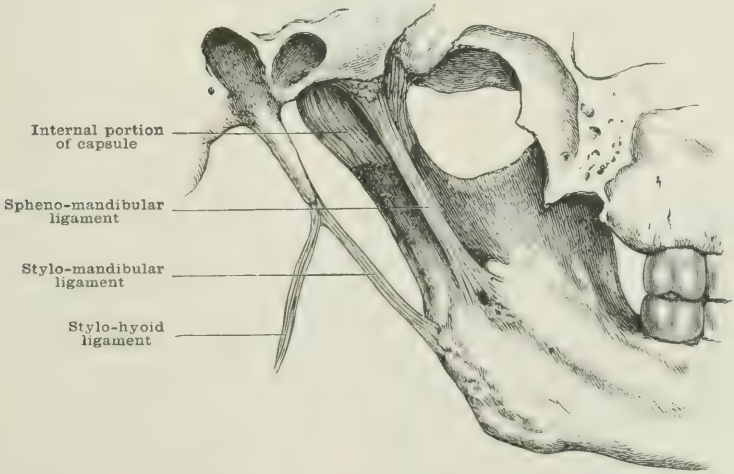

External portion of capsule
Stylo-mandibular ligament

FIG. 192.—INTERNAL VIEW OF TEMPORO-MANDIBULAR JOINT.


Internal portion of capsule
Spheno-mandibular ligament
Stylo-mandibular ligament
Stylo-hyoid ligament

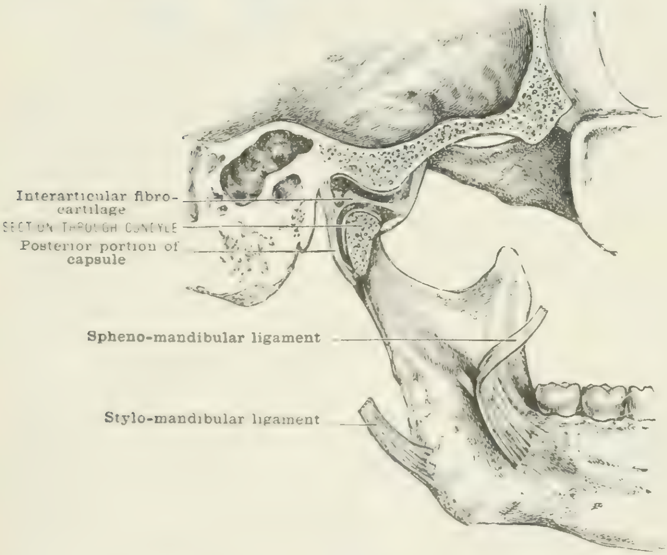
The **arterial supply** is derived from the temporal, middle meningeal, and ascending pharyngeal by its branches to the Eustachian tube.

The **nerves** are derived from the masseteric and auriculo-temporal.

Movements.—The chief movement of this joint is of (i) a **ginglymoid or hinge character**, accompanied by a slight gliding action, as in opening or shutting the mouth. In the opening movement the condyle turns like a hinge on the fibro-cartilage, while at the same time the fibro-cartilage, together with the condyle, glides forwards so as to rise upon the eminentia articularis; the fibro-cartilage reaching as far as the anterior edge of the eminence, which is coated with articular cartilage to receive it: but the condyle never reaches quite so far as the summit of the eminence. Should the condyle, however, by excessive movement (as in a convulsive yawn), glide over the summit, it slips into the zygomatic fossa, the mandible is dislocated, and the posterior portion of the capsule is torn. In the shutting movement the condyle revolves back again, and the fibro-cartilage glides back, carrying the condyle with it. This combination of the hinge and gliding motions gives a tearing as well as a cutting action to the incisor teeth, without any extra muscular exertion.

There is (ii) a **horizontal gliding action** in an antero-posterior direction, by which the lower teeth are thrust forwards and drawn back again: this takes place almost entirely in the upper compartment, because of the closer connection of the fibro-cartilage with the condyle than with the squamosal bone, and also because of the insertion of the *external pterygoid* into both bone and cartilage. In these two sets of movements the joints of both sides are simultaneously and similarly engaged.

FIG. 193.—VERTICAL SECTION THROUGH THE CONDYLE OF JAW TO SHOW THE TWO SYNOVIAL SACS AND THE INTERARTICULAR FIBRO-CARTILAGE.


Interarticular fibro-cartilage
SECTION THROUGH CONDYLE
Posterior portion of capsule
Spheno-mandibular ligament
Stylo-mandibular ligament

The third form of movement is called (iii) the **oblique rotatory**, and is that by which the grinding and chewing actions are performed. It consists in a rotation of the condyle about the vertical axis of its neck in the lower compartment, while the cartilage glides obliquely forwards and inwards on one side, and backwards and inwards on the other, upon the articular surface of the squamosal bones, each side acting alternately. If the symphysis be simply moved from the centre to one side and back again, and not from side to side as in grinding, the condyle of that side moves round the vertical axis of its neck, and the opposite condyle and cartilage glide forwards and inwards upon the glenoid fossa. But in the ordinary grinding movement, one condyle advances and the other recedes, and then the first recedes while the other advances, slight rotation taking place in each joint meanwhile.

(2) THE LIGAMENTS AND JOINTS BETWEEN THE SKULL AND SPINAL COLUMN, AND BETWEEN THE ATLAS AND AXIS

(*a*) The Articulation of the Atlas with the Occiput

Class.—*Diarthrosis.* **Subdivision.**—*Double Condylarthrosis.*

This articulation consists of a pair of joints symmetrically situated on either side of the middle line. The parts entering into their formation are the cup-shaped superior articular processes of the atlas, and the condyles of the occipital bone. They are united by the following ligaments:—

1. Anterior occipito-atlantal.
2. Posterior occipito-atlantal.
3. Two capsular.
4. Two anterior oblique.

The **anterior occipito-atlantal ligament** (fig. 194) is less than an inch (about 2 cm.) wide, and is composed of densely woven fibres, most of which radiate slightly outwards as they ascend from the front surface and upper margin of the anterior arch of the atlas, to the anterior border of the foramen magnum; it is continuous laterally with the capsular ligaments, the fibres of which overlap its edges, and take an opposite direction inwards and upwards. The central fibres ascend vertically from the anterior tubercle of the atlas to the pharyngeal tubercle on the occipital bone; they are thicker than the lateral fibres, and are continuous below with the superficial part of the anterior atlanto-axoidean ligament, and through it with the anterior common ligament of the vertebral column. It is in relation, in front, with the *recti capitis antici minores;* and behind, with the central odontoid or suspensory ligament.

The **posterior occipito-atlantal ligament** (fig. 195) is broader, more membranous, and not so strong as the anterior. It extends from the posterior surface and upper border of the posterior arch of the atlas to the posterior margin of the foramen magnum from condyle to condyle; being incomplete on either side for the passage of the *vertebral artery* into, and *suboccipital nerve* out of, the canal. It is somewhat thickened in the middle line by fibres, which pass from the posterior tubercle of the atlas to the lower end of the occipital crest. It is not tightly stretched between the bones, nor does it limit their movements: it corresponds with the position of the ligamenta subflava, but has no elastic tissue in its composition. It is in relation in front with the dura mater, which is firmly attached to it; and behind with the *recti capitis postici minores*, and enters into the floor of the suboccipital triangle.

The **capsular ligaments** (figs. 194 and 195) are very distinct and strongly marked, except on the inner side, where they are thin and formed only of short membranous fibres. They are lax, and do not add much to the security of the joint. In front, the capsule descends upon the atlas, to be attached, some distance below the articular margin, to the front surface of the lateral mass, and to the base of the transverse process; these fibres take an oblique course upwards and inwards, overlapping the anterior occipito-atlantal. At the sides and behind, the capsule is attached above to the margins of the occipital condyles; below, it skirts the inner edge of the foramen for the vertebral artery, and behind is attached to the prominent tubercle overhanging the groove for that vessel; these latter fibres are strengthened by a band running obliquely upwards and inwards to the posterior margin of the foramen magnum.

The **anterior oblique** or **lateral occipito-atlantal ligament** (fig. 194) is an accessory band which strengthens the capsule on the outer side. It is an oblique, thick band of fibres, sometimes quite separate and distinct from the rest, passing upwards and inwards from the upper surface of the transverse process beyond the costo-vertebral foramen to the jugular process of the occipital bone.

The **synovial membrane** of these joints occasionally communicates with the synovial sac between the odontoid process and the transverse ligament.

The **arterial** supply is derived from twigs of the vertebral, and occasionally from twigs from the meningeal branches of the ascending pharyngeal.

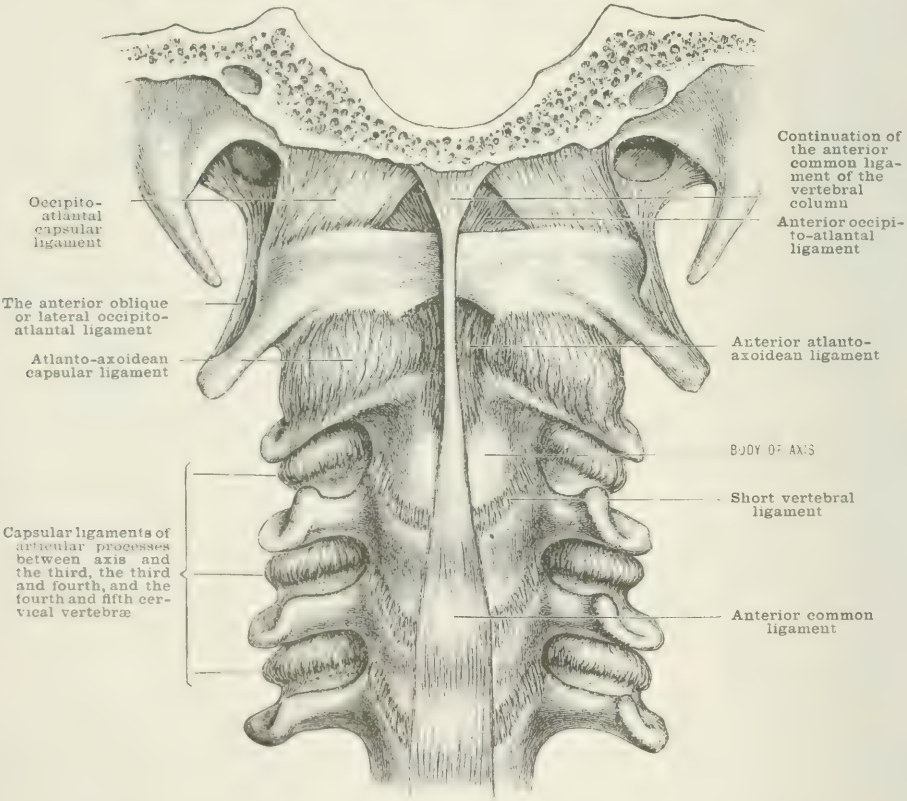
The **nerve-supply** comes from the anterior division of the suboccipital nerve.

Movements.—By the symmetrical and bilateral arrangement of these joints, security and strength are gained at the expense of a very small amount of actual articular surface; the basis of support and the area of action being equal to the width between the most distant borders of the joint.

The principal movement permitted at these joints is of a ginglymoid character, producing flexion and extension upon a transverse axis drawn across the condyles at their slightly constricted parts.

In flexion, the forehead and chin drop, and what is called the nodding movement is made; in extension, the chin is elevated and the forehead recedes.

Fig. 194. Anterior View of the Upper End of the Spine.


Continuation of the anterior common ligament of the vertebral column
Occipito-atlantal capsular ligament
Anterior occipito-atlantal ligament
The anterior oblique or lateral occipito-atlantal ligament
Anterior atlanto-axoidean ligament
Atlanto-axoidean capsular ligament
BODY OF AXIS
Short vertebral ligament
Capsular ligaments of articular processes between axis and the third, the third and fourth, and the fourth and fifth cervical vertebræ
Anterior common ligament

There is also a slight amount of gliding movement, either **directly lateral,** the outer edge of one condyle sinking a little within the outer edge of the socket of the atlas, and that of the opposite condyle projecting to a corresponding degree. The head is thus tilted to one side, and it is even possible that the weight of the skull may be borne almost entirely on one joint, the articular surfaces of the other being thrown out of contact.

Or the movement may be **obliquely lateral,** when the lower side of the head will be a trifle in advance of the elevated side. In this motion, which takes place on the antero-posterior axis, one condyle advances slightly and approaches the middle line, while the other recedes. This is of the nature of rotation, though there is no true rotation round a vertical axis possible between the occiput and atlas.

These lateral movements are checked by the lateral odontoid ligaments and the outer part of the capsules; extension is checked by the anterior occipito-atlantal and anterior oblique ligaments, and flexion by the posterior part of the capsule and cervico-basilar ligaments.

(*b*) THE ARTICULATIONS BETWEEN THE ATLAS AND AXIS

1. THE LATERAL ATLANTO-AXOIDEAN JOINTS.	**Class.**—*Diarthrosis.* **Subdivision.**—*Arthrodia.*
2. THE CENTRAL ATLANTO-AXOIDEAN JOINT, OR THE ATLANTO-ODONTOID.	**Class.**—*Diarthrosis.* **Subdivision.**—*Trochoides.*

The bones that enter into the formation of the lateral joints are the inferior articular processes of the atlas and the superior of the axis; the central joint is formed by the odontoid process articulating in front with the atlas, and behind with the transverse ligament.

The ligaments which unite the axis and atlas are:—

1. The anterior atlanto-axoidean.
2. The posterior atlanto-axoidean.
3. Two capsular (for lateral joints).
4. The transverse ligament.
5. The atlanto-odontoid capsular ligament.

The **anterior atlanto-axoidean ligament** (figs. 194 and 195) is a narrow but strong membrane filling up the interval between the lateral joints. It is attached above to the front surface and lower border of the anterior arch of the atlas, and below to the transverse ridge on the front of the body of the axis. Its fibres are vertical, and are thickened in the median line by a dense band which is a continuation upwards of the anterior common ligament of the spine.

This band is fixed above to the anterior tubercle of the atlas, where it becomes continuous with the central part of the anterior occipito-atlantal ligament (fig. 194); it is sometimes separated by an interval from the deeper ligament, and is often described as the superficial atlanto-axoidean ligament. It is in relation with the *longus colli* muscle.

The **posterior atlanto-axoidean ligament** (fig. 195) is a deeper, but thinner and looser membrane than the anterior. It extends from the posterior root of the transverse process of one side to that of the other, projecting outwards beyond the posterior part of the capsules which are connected with it. It is attached above to the posterior surface and lower edge of the posterior arch of the atlas, and below to the superior edge of the laminæ of the axis on their dorsal aspect. It is denser and stronger in the median line, and has a layer of elastic tissue on its anterior surface like the ligamenta subflava, to which it corresponds in position. It is connected in front with the dura mater; behind, it is in relation with the *inferior oblique* muscles, and is perforated at each side by the *second cervical* nerve.

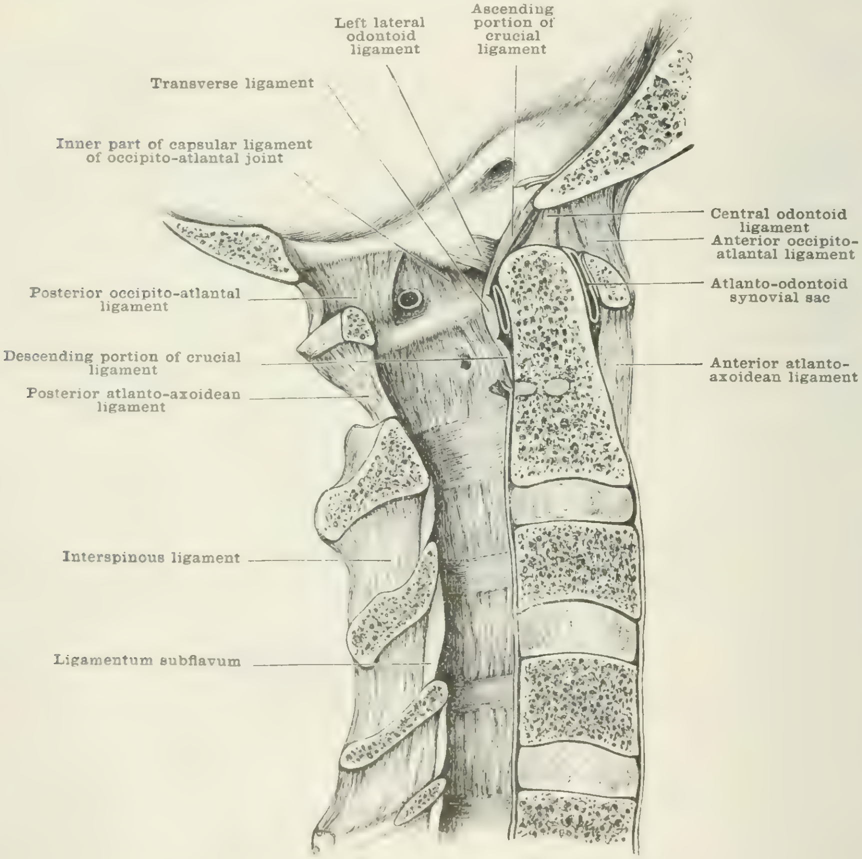
1. THE LATERAL ATLANTO-AXOIDEAN JOINTS are provided with short, ligamentous fibres, forming **capsular ligaments** (fig. 194), which completely surround the lateral articular facets. Outside the canal, they are attached some little distance from the articular margins, extending along the roots of the transverse processes of the axis nearly as far as the tips, but between the roots they skirt the inner edge of the costo-vertebral foramina. They are strengthened in front and behind by the atlanto-axoidean ligaments. Internally each capsule is thinner, and attached close to the articular margins, being strengthened behind by a strong band of slightly oblique fibres passing upwards along the outer edge of the cervico-basilar ligament from the body of the axis to the lateral mass of the atlas behind the transverse ligament; some of these fibres pass on, thickening and blending with the occipito-atlantal capsule, to be inserted into the margin of the foramen magnum. This band is sometimes called the **accessory band** (fig. 198).

There is a **synovial sac** for each joint.

2. The CENTRAL ATLANTO-AXOIDEAN JOINT, although usually described as one, is composed of two articulations, which are quite separate from one another: an anterior between the odontoid process and the arch of the atlas, and a posterior between the odontoid process and the transverse ligament.

The **transverse ligament** (figs. 195, 196, and 198) is one of the most important structures in the body, for on its integrity and that of the check ligaments our lives largely depend. It is a thick and very strong band, as dense and closely woven as fibro-cartilage, about a quarter of an inch (6 mm.) deep at the sides, and somewhat more in the middle line. Attached at each end to a tubercle on the inner side of the lateral mass of the atlas, it crosses the ring of this bone in a curved manner, so as to have the concavity forward; thus dividing the ring into a smaller anterior portion for the odontoid process, and a larger posterior part for the spinal cord and its membranes, and the spinal accessory nerves. It is flattened from before backwards, being smooth in front, and covered by synovial membrane to allow it to glide freely over the posterior facet of the odontoid process. Where it is attached to the atlas it is smooth and well rounded off to provide an easy floor of communication between the transverso-odontoid and occipito-atlantal joints.

FIG. 195.—VERTICAL ANTERO-POSTERIOR SECTION OF SPINAL COLUMN THROUGH MEDIAN LINE, SHOWING LIGAMENTS.


Left lateral odontoid ligament
Ascending portion of crucial ligament
Transverse ligament
Inner part of capsular ligament of occipito-atlantal joint
Central odontoid ligament
Anterior occipito-atlantal ligament
Atlanto-odontoid synovial sac
Posterior occipito-atlantal ligament
Descending portion of crucial ligament
Anterior atlanto-axoidean ligament
Posterior atlanto-axoidean ligament
Interspinous ligament
Ligamentum subflavum

To its posterior surface is added, in the middle line, a strong fasciculus of vertical fibres, passing upwards from the root of the odontoid process to the basilar border of the foramen magnum on its cranial aspect. Some of these fibres are derived from the transverse ligament. These vertical fibres give the transverse ligament a cruciform appearance; hence the name, the **crucial ligament** (figs. 195 and 198) applied to the whole.

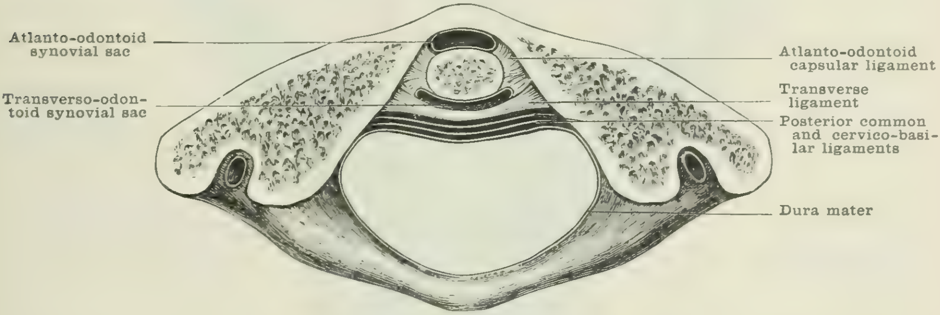
The **atlanto-odontoid capsular ligament** (fig. 196) is a tough, loose membrane, completely surrounding the apposed articular surfaces of the atlas and odontoid process. At the odontoid process it blends above with the front of the check and central occipito-odontoid ligaments, and arises also along the sides of the articular facet as far as the neck of the process; the fibres are thick, and blend with the capsules of the lateral joint. At the atlas they are attached to the non-articular part of the anterior arch in front of the tubercles for the transverse ligament, blending, above and below the borders of the bone, with the anterior occipito-atlantal and atlanto-axoidean ligaments, as well as with the inner portion of the capsular ligaments. It holds the axis to the anterior arch of the atlas after all the other ligaments have been divided.

The **synovial membranes** (figs. 195 and 196) are two in number:—one for the joint between the odontoid process and atlas; and another (transverso-odontoid) for that between the transverse ligament and the odontoid. This last often communicates with the occipito-atlantal articulations; it is closed in by membranous tissue between the borders of the transverse ligament and the margin of the facet on the odontoid, and is separated from the front sac by the atlanto-odontoid capsular ligament.

The **arterial supply** is from the vertebral artery, and the **nerve-supply** from the loop between the first and second cervical nerves.

Movements.—The chief and characteristic movement at these joints is the rotation, in a nearly horizontal plane, of the collar formed by the atlas and transverse ligament, round the odontoid process as a pivot, which is extensive enough to allow of an all-round view without twisting the trunk. Partly on account of its ligamentous attachments, and partly on account of the shape of the articular surfaces, the cranium must be carried with the atlas in these movements. The rotation is checked by the ligaments passing from the axis to the occiput (check ligaments), and also by the atlanto-axoidean. Owing to the fact that the facets of both atlas and axis, which enter into the formation of the lateral atlanto-axoidean articulations, are convex from before backwards, and have the articular cartilage thicker in the centre than at the circumference, the motion is not quite horizontal but slightly curvilinear. In the erect position, with the face looking directly forwards, the most convex portions of the articular surfaces are alone in contact, there being a considerable interval between the edges; during rotation, therefore, the prominent portions of the condyles of the atlas descend upon those of the axis, diminishing the space between the bones, slackening the ligaments, and thus increasing the amount of rotation, without sacrificing the security of the joint in the central position.

FIG. 196.—HORIZONTAL SECTION THROUGH THE LATERAL MASSES OF THE ATLAS AND THE TOP OF THE ODONTOID PROCESS.


Atlanto-odontoid synovial sac
Transverso-odontoid synovial sac
Atlanto-odontoid capsular ligament
Transverse ligament
Posterior common and cervico-basilar ligaments
Dura mater

Besides rotation, forward and backward movements and some lateral flexion are permitted between the atlas and axis, even to a greater extent than in most of the other vertebral joints.

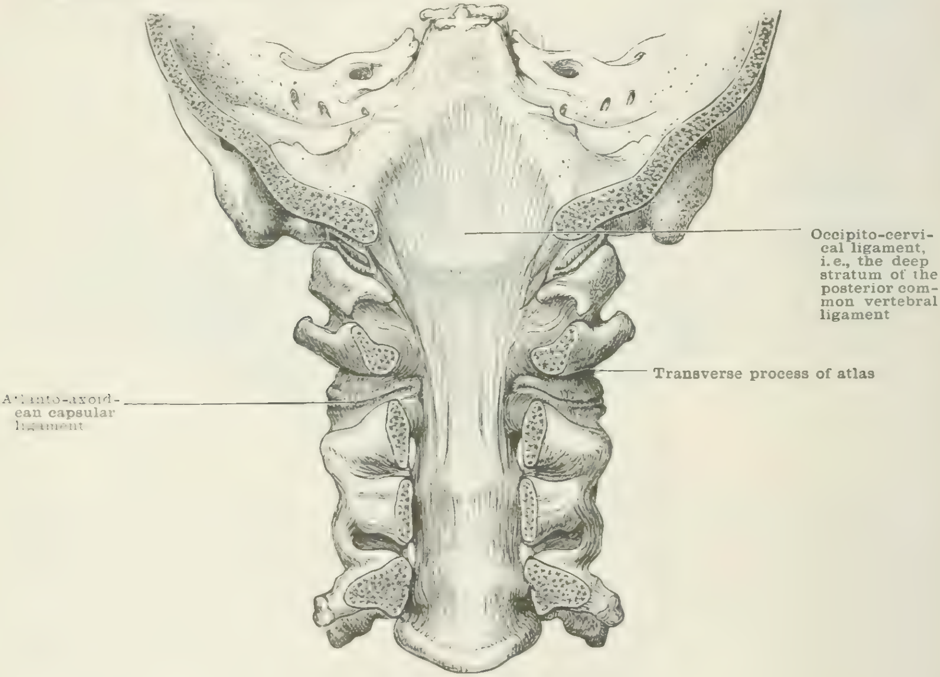
(c) THE LIGAMENTS UNITING THE OCCIPUT AND AXIS

The following ligaments unite bones not in contact, and are to be seen from the interior of the canal after removing the posterior arches of axis and atlas and posterior ring of the foramen magnum:—

1. The occipito-cervical.
2. The crucial.
3. Two lateral odontoid or check.
4. The central odontoid or suspensory.

The **occipito-cervical** or **cervico-basilar ligament** (figs. 196, 197, and 198) consists of a very strong band of fibres, connected below to the upper part of the body of the third vertebra and lower part of the body of the axis as far as the root of the odontoid process. It is narrow below, but widens out as it ascends, to be fastened to the basilar groove of the occiput. Laterally, it is connected with the accessory fibres of the atlanto-axoidean capsule. It is really only the upward prolongation of the deep stratum of the posterior common ligament, the superficial fibres of which run on to the occipital bone without touching the axis, thus giving rise to two strata. It is in relation in front with the crucial ligament.

FIG. 197.—THE SUPERFICIAL LAYER OF THE POSTERIOR COMMON VERTEBRAL LIGAMENT HAS BEEN REMOVED TO SHOW ITS DEEP OR SHORT FIBRES. THESE DEEP FIBRES FORM THE OCCIPITO-CERVICAL LIGAMENT.


Occipito-cervical ligament, i.e., the deep stratum of the posterior common vertebral ligament
Transverse process of atlas
Atlanto-axoidean capsular ligament

The **crucial ligament** has been already described (see page 186).

The **lateral occipito-odontoid** or **check ligaments** (figs. 195 and 198) are two strong rounded cords, which extend from the sides of the apex of the odontoid process, transversely outwards to the inner edge of the anterior portion of the occipital condyles. They are to be seen immediately above the upper border of the transverse ligament, which they cross obliquely owing to its forward curve at its attachments to the atlas. Some of their fibres occasionally run across the middle line from one check ligament to the other. At the odontoid process they are connected with the atlanto-odontoid capsule, and at the condyles they strengthen the occipito-atlantal capsular ligaments.

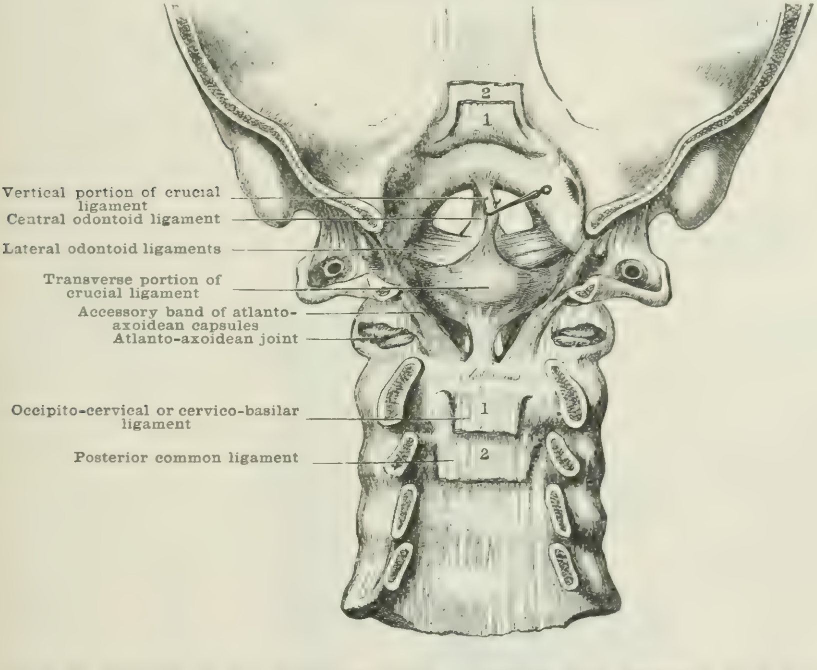
The **central odontoid** or **suspensory ligament** (figs. 195 and 198) consists of a slender band of fibres ascending from the summit of the odontoid process to the under surface of the occipital bone, close to the foramen magnum. It is best seen from the front, after removing the anterior occipito-atlantal ligament, or from behind by drawing aside the crucial ligament.

The suspensory ligament is tightened by extension and relaxed by flexion or nodding; the lateral odontoids not only limit the rotatory movements of the head and atlas upon the axis, but by binding the occiput to the pivot, round which rotation occurs, they steady the head and prevent its undue lateral inclination upon the spine. (See Transverse Ligament, p. 186.)

By experiments, it has been proved that the head, when placed so that the orbits look a little upwards, is poised upon the occipital condyles in a line drawn a little in front of their middle; the amount of elevation varies slightly in different cases, but the balance is always to be obtained in the human body—it is one of the characteristics of the human figure. It serves to maintain the head erect without undue muscular effort, or a strong ligamentum nuchae and prominent dorsal spines such as are seen in the lower animals. Disturb this balance, and let the muscles cease to act, the head will either drop forwards or backwards according as the centre of the gravity is in front or behind the balance line. The ligaments which pass over the odontoid process to the occiput are not quite tight when the head is erect, and only become so when the head is flexed; if this were not so, no flexion would be allowed; thus, muscular action, and not ligamentous tension, is employed to steady the head in the erect position. It is through the combination of the joints of the atlas and axis, and occiput and atlas (consisting of two pairs of joints placed symmetrically on either side of the median line, while through the median line there passes a pivot, also with a pair of joints) that the head enjoys such freedom and celerity of action, remarkable strength, and almost absolute security against violence, which could only be obtained by a ball-and-socket joint; but the ordinary ball-and-socket joints are too prone to dislocations by even moderate twists to be reliable enough when the life of the individual depends on the perfection of the articulation: hence the importance of this combination of joints.

FIG. 198.—VERTICAL TRANSVERSE SECTION OF THE SPINAL COLUMN AND THE OCCIPITAL BONE TO SHOW LIGAMENTS.

(The cervico-basilar (1), though shown as a distinct stratum, is really the deeper part of the posterior common ligament (2).)


2
1
Vertical portion of crucial ligament
Central odontoid ligament
Lateral odontoid ligaments
Transverse portion of crucial ligament
Accessory band of atlanto-axoidean capsules
Atlanto-axoidean joint
Occipito-cervical or cervico-basilar ligament
1
Posterior common ligament
2

THE ARTICULATIONS OF THE TRUNK

These may be divided into the following sets:—

1. Those of the vertebral column.
    (*a*) Union of the bodies.
    (*b*) Union of the articular processes.
2. Vertebral column with the pelvis.
3. Pelvis.
    (*a*) Sacro-iliac synchondroses.
    (*b*) Sacro-coccygeal.
    (*c*) Intercoccygeal.
    (*d*) Symphysis pubis.
4. Ribs with the vertebral column.
5. The articulations at the front of the thorax.
    (*a*) Costal cartilages with the sternum.
    (*b*) Costal cartilages with the ribs.
    (*c*) Sternal.
    (*d*) Certain costal cartilages with each other.

1. THE ARTICULATIONS OF THE VERTEBRAL COLUMN

There are two distinct sets of articulations in the vertebral column:—

(*a*) Those between the bodies and intervertebral discs which form amphiarthrodial joints.
(*b*) Those between the articular processes which form arthrodial joints.

The ligaments which unite the various parts may also be divided into two sets, viz.—**immediate,** or those that bind together parts which are in contact; and **intermediate,** or those that bind together parts which are not in contact.

Immediate.
(*a*) Those between the bodies and discs.
(*b*) Those between the articular processes.

Intermediate.
(*c*) Those between the laminæ.
(*d*) Those between the spinous processes.
(*e*) Those between the transverse processes.

(*a*) The Articulations of the Bodies of the Vertebræ

Class.—*Amphiarthrosis.*

The ligaments which unite the bodies of the vertebræ are:—

Intervertebral discs.
Short lateral ligaments.
Anterior common.
Posterior common.

The **intervertebral substances** (figs. 195 and 199) are tough, but elastic and compressible discs of composite structure, which serve as the chief bond of union between the vertebræ. They are twenty-three in number, and are interposed between the bodies of all the vertebræ from the axis to the sacrum (figs. 195 and 206). Similar substances are found between the segments of the sacrum and coccyx, but they undergo ossification at their surfaces and often throughout their whole extent.

Each disc is composed of two portions—a circumferential laminar, and a central pulpy portion; the former tightly surrounds and braces in the latter, and forms somewhat more than half the disc. The **laminar portion** consists of alternating layers of fibrous tissue and fibro-cartilage; the component fibres of these layers are firmly connected with two vertebræ, those of one passing obliquely down and to the right, those of the next down and to the left, making an X-shaped arrangement of the alternate layers. A few of the superficial lamellæ project beyond the edges of the bodies, their fibres being connected with the edges of the anterior and

FIG. 199.—HORIZONTAL SECTION THROUGH AN INTERVERTEBRAL DISC AND THE CORRESPONDING RIBS.

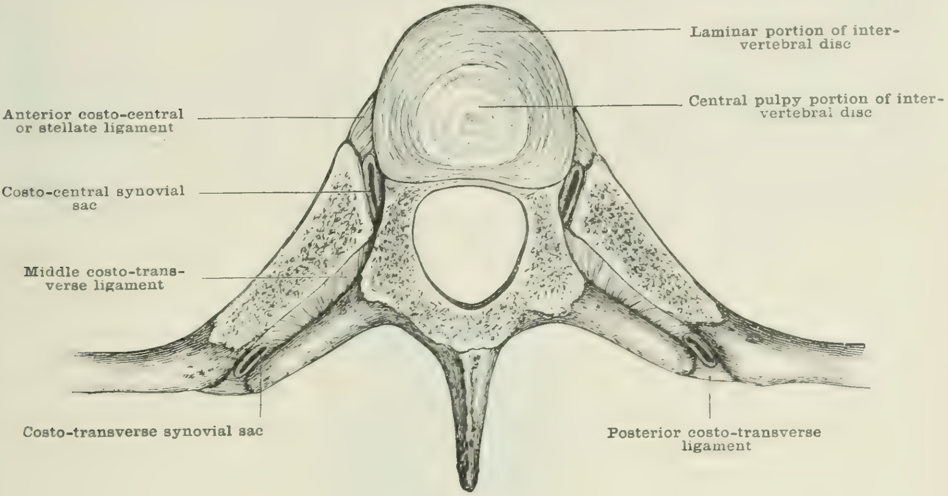
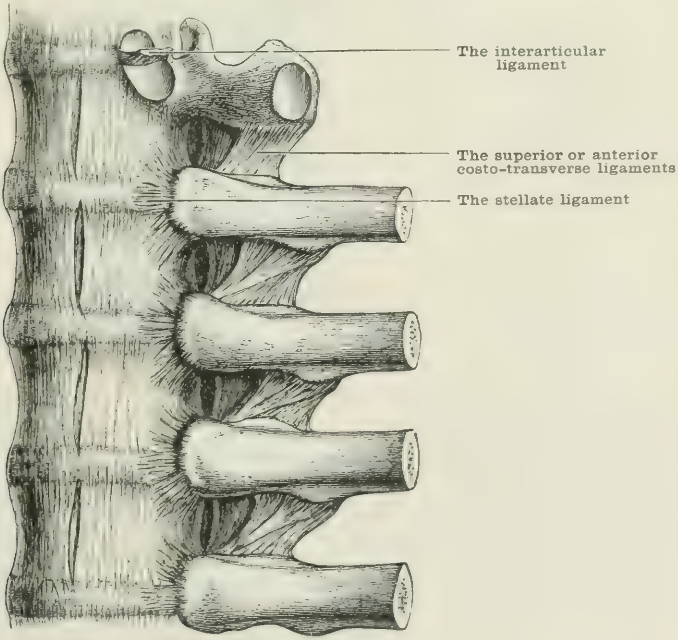

Laminar portion of intervertebral disc
Central pulpy portion of intervertebral disc
Anterior costo-central or stellate ligament
Costo-central synovial sac
Middle costo-transverse ligament
Costo-transverse synovial sac
Posterior costo-transverse ligament

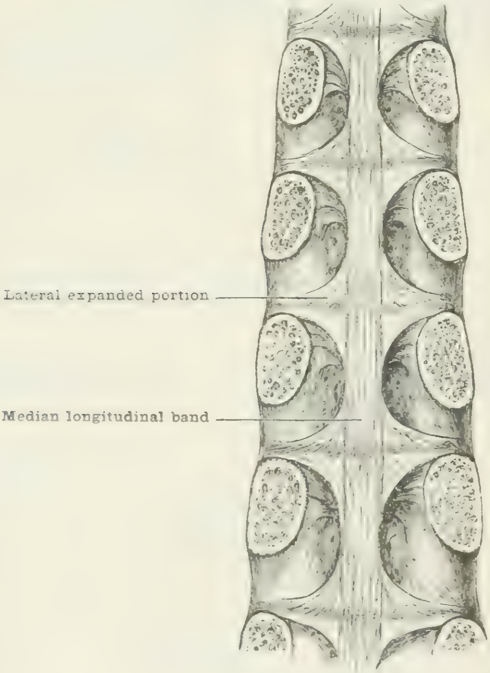
FIG. 200.—THE ANTERIOR COMMON LIGAMENT OF THE SPINE, THE STELLATE, THE INTERARTICULAR, AND THE SUPERIOR COSTO-TRANSVERSE LIGAMENTS.


The interarticular ligament
The superior or anterior costo-transverse ligaments
The stellate ligament

lateral surfaces; and some do not completely surround the rest, but terminate at the intervertebral foramina, so that on horizontal section the circumferential portion is seen to be thinner posteriorly. The more central lamellæ are incomplete, less firm, and not so distinct as the rest; and as they near the pulp they gradually assume its characters, becoming more fibro-cartilaginous and less fibrous, and have cartilage cells in their structure.

The **central portion** is situated somewhat behind the centre of the disc, forming a ball of very elastic and tightly compressed material, which bulges freely when the confining pressure of the laminar portion is removed by either horizontal or vertical section. Thus, it has a constant tendency to spring out of its confinement in the direction of least resistance, and constitutes a pivot round which the bodies of the vertebræ can twist, tilt, or incline. It is yellowish in colour, and is composed of a fine fibrous matrix containing cartilage cells and fluid in its meshes. Together with the most central laminæ, it is separated from immediate contact with the bone by a thin plate of articular cartilage. The central pulp of the intervertebral substance is the persistent part of the notochord.

Fig. 201.—Posterior Common Ligament of the Spine. (Thoracic region.)
(Pedicles cut through, and posterior arches of vertebræ removed.)

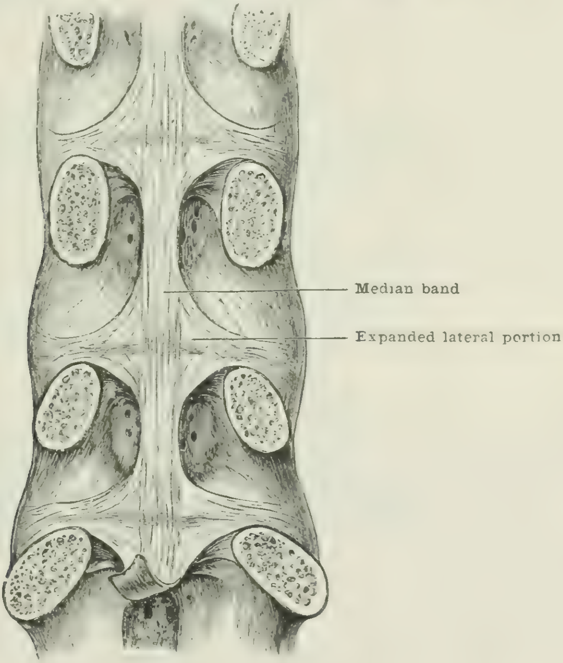


The intervertebral substances vary in shape with the bodies of the vertebræ they unite, and are widest and thickest in the lumbar region. In the cervical and lumbar regions they are thicker in front than behind, and *cause* the convexity forwards of the cervical, and *increase* that of the lumbar; the curve in the thoracic region, almost entirely due to the shape of the bodies, is, however, somewhat increased by the discs. Without the discs the column loses a quarter of its length, and assumes a curve with the concavity forwards, most marked a little below the mid-thoracic region. Such is the curve of old age, which is due to the shrinking and drying up of the intervertebral substances. The disc between the axis and third cervical is the thinnest of all (fig. 195); that between the fifth lumbar and sacrum is the thickest, and is much thicker in front than behind (fig. 206). The intervertebral discs are in relation, in front with the anterior common ligament;

behind, with the posterior common ligament; laterally, with the short lateral; and in the thoracic region with the interarticular and stellate ligaments.

The **anterior common ligament** (figs. 194 and 200) commences as a narrow band attached to the under surface of the occipital bone in the median line, just in front of the occipito-atlantal ligament, of which it forms the thickened central portion. Attached firmly to the tubercle of the atlas, it passes down as the central portion of the atlanto-axoidean ligament, in the mid-line, to the front of the body of the axis. It now begins to widen out as it descends, until it is nearly two inches (5 cm.) wide in the lumbar region. Below, it is fixed to the upper segment of the sacrum, becoming lost in periosteum about the middle of that bone; but is again distinguishable in front of the sacro-coccygeal joint, as the anterior sacro-coccygeal ligament. Its structure is bright, pearly-white, and glistening with well-defined borders best marked in the thoracic region. It is thickest in the thoracic region, and thicker in the lumbar than the cervical. It is firmly connected with the bodies of the vertebræ, and is composed of longitudinal fibres, of which the superficial extend over several, while the deeper pass over only two or three vertebræ. It is connected with the tendinous expansion of the prevertebral muscles in the cervical, and the crura of the diaphragm are closely attached to it in the lumbar region.

FIG. 202.—POSTERIOR COMMON LIGAMENT. (Lumbar region.)



The **posterior common ligament** (figs. 198, 201, 202, and 209) extends from the occipital bone to the coccyx. It is wider above than below, and commences by a broad attachment to the cranial surface of the basi-occipital. In the cervical region it is of nearly uniform width, and extends completely across the bodies of the vertebræ, upon which it rests quite flat. It does, however, extend slightly further outwards on each side opposite the intervertebral discs. In the thoracic and lumbar regions it is distinctly dentated, being broader over the intervertebral substances and the edges of the bones, than over the middle of the bodies, where it is a narrow band stretched over the bones without resting on them, some areolar tissue and blood-vessels being interposed. The narrow median portion consists of longitudinal fibres, some of which are superficial and pass over several vertebræ;

and others are deeper, and extend only from one vertebra to the next but one below.

The dentated or broader portions (fig. 202) are formed by oblique fibres which, springing from the bodies near the intervertebral foramina, take a curved course downwards and backwards over an intervertebral substance, and reach the narrow portion of the ligament on the centre of the vertebra next below: they then diverge to pass over another intervertebral disc to end on the body of the vertebra beyond, near the intervertebral notch. They thus pass over two discs and three vertebræ. Deeper still are other fibres thickening these expansions of the common ligament, and extending from one bone to the next.

The last well-marked expansion is situated between the first two segments of the sacrum: below this, the ligament becomes a delicate central band with rudimentary expansions, being more pronounced again over the sacro-coccygeal joint, and losing itself in the ligamentous tissue at the back of the coccyx. The dura mater is tightly attached to it at the occipital bone and margin of the foramen magnum, but is separated from it in the rest of its extent by loose cellular tissue. The filum terminale becomes blended with it at the lower part of the sacrum and back of the coccyx.

The **lateral** or **short vertebral ligaments** (fig. 200) consist of numerous short fibres situated between the anterior and posterior common ligaments, and passing from one vertebra over the intervertebral disc, to which it is firmly adherent, to the next vertebra below. The more superficial fibres are more or less vertical, but the deeper decussate and have a crucial arrangement. They are connected with the deep surface of the anterior common ligament, and so tie it to the edges of the bodies of the vertebræ and to the intervertebral discs. They blend behind with the expansions of the posterior common ligament, and so complete the casing round each amphiarthrodial joint. In the thoracic region, they overlie the stellate ligament, and in the lumbar they radiate towards the transverse processes. In the cervical region they are less well marked.

(*b*) The Ligaments connecting the Articular Processes

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

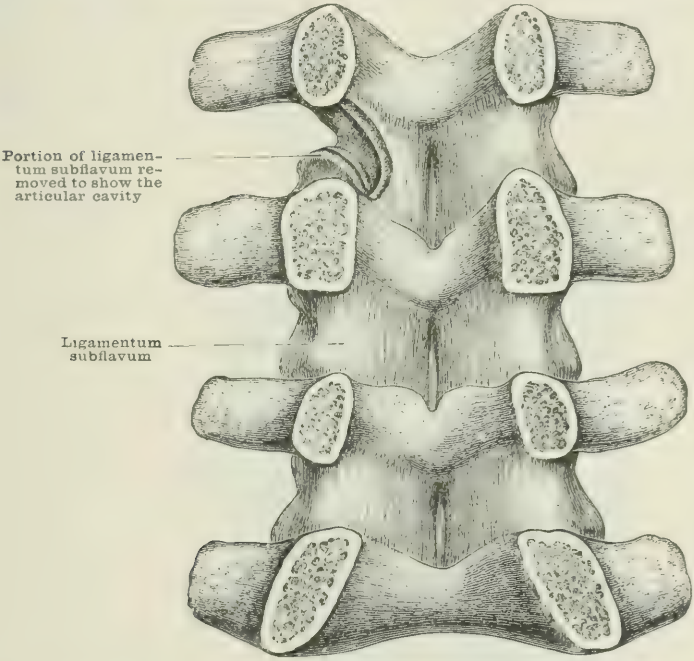
The **capsular ligaments** (fig. 194) which unite these processes are composed partly of yellow elastic tissue, and partly of white fibrous tissue. In the cervical region only the inner side of the capsule is formed by the ligamenta subflava, which in the thoracic and lumbar regions, however, extend anteriorly to the margins of the intervertebral foramina. The part formed of white fibrous tissue consists of short, well-marked fibres, which in the cervical region pass obliquely downwards and forwards over the joint, between the articular processes and the posterior roots of the transverse processes of two contiguous vertebræ. In the thoracic region the fibres are shorter, and vertical in direction, and are attached to the bases of the transverse processes; in the lumbar, they are obliquely transverse. The capsular ligaments in the cervical region are the most lax, those in the lumbar region are rather tighter, and those in the thoracic region are the tightest.

There is one **synovial membrane** to each capsule.

(*c*) The Ligaments uniting the Laminæ

The **ligamenta subflava** (fig. 203) are shallow plates of closely-woven yellow elastic tissue, interposed between the laminæ of two adjacent vertebræ. The first connects the axis with the third cervical, and the last the fifth lumbar with the sacrum. Each ligament extends from the inner and posterior edge of the intervertebral foramen on one side to a corresponding point on the other; above, it is attached close to the inner margin of the inferior articular process and to a well-marked ridge on the inner surface of the laminæ as far as the root of the spine; below, it is fixed close to the inner margin of the superior articular process and to the dorsal aspect of the upper edge of the laminæ. Thus each, besides filling up the interlaminar space, enters into the formation of two capsular ligaments; they do so to a greater extent in the thoracic and lumbar regions than in the cervical, where the articular processes are placed wider apart. When seen from the front after removing the bodies of the vertebræ, they are concave from side to side, but convex from above downwards; they make a more decided transverse curve than the arches between which they are placed. This concavity is more marked in the thoracic, and still more in the lumbar region than in the cervical; in the lumbar region the ligamenta subflava extend a short distance between the roots of the spinous process, blending with the interspinous ligament, and making a median sulcus when seen from the front; there is, however, no separation between the two parts. In the cervical region, where the spines are bifid, there is a median fissure in the yellow tissue which is filled up by fibro-areolar tissue. The ligaments are thickest and strongest in the lumbar region; narrow but strong in the thoracic; thinner, broader, and more membranous in the cervical region.

FIG. 203.—LIGAMENTA SUBFLAVA IN THE LUMBAR REGION, SEEN FROM WITHIN THE SPINAL CANAL.


Portion of ligamentum subflavum removed to show the articular cavity
Ligamentum subflavum

(*d*) THE LIGAMENTS CONNECTING THE SPINOUS PROCESSES WITH ONE ANOTHER

Supraspinous ligament, interspinous ligaments, and the ligamentum nuchæ.

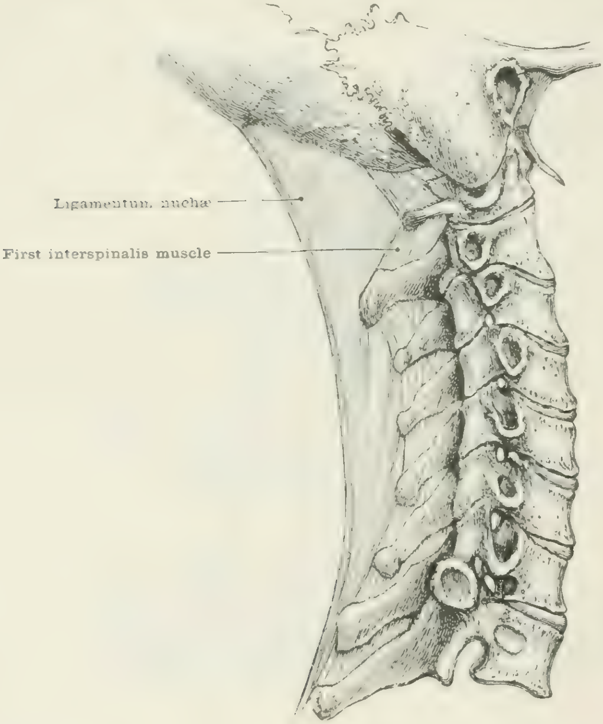
The **supraspinous ligament** (fig. 205) extends, without interruption, as a well-marked band of longitudinal fibres along the tips of the spines of the vertebræ from that of the seventh cervical downwards till it blends with the fibrous tissue on the back of the coccyx. It covers in the lower end of the spinal canal, and adds to the security of the sacro-coccygeal articulation.

Its more superficial fibres are much longer than the deep. The deeper fibres pass over adjacent spines only, while the superficial overlie several. It is connected laterally with the aponeurotic structures of the back; indeed, in the lumbar region, where it is well marked, it appears to result from the interweaving of the tendinous fibres of the several muscles which are attached to the tips of the spinous processes.

In the dorsal region it is a round slender cord which is put on the stretch in flexion and relaxed in extension of the back.

The **ligamentum nuchæ**, or the **posterior cervical ligament** (fig. 204), is the continuation in the neck of the supraspinous ligament, from which, however, it differs considerably. It is a slender vertical septum of an elongated triangular form, extending from the seventh cervical vertebra to the external protuberance and the crest of the occipital bone. Its anterior border is firmly attached to the tips of the spines of all the cervical vertebræ, including the posterior tubercle of the atlas, as well as to the occiput. Its posterior border gives origin to the trapezii, with the tendinous fibres of which muscles it blends. Its lateral, triangular surfaces afford numerous points of attachment for the posterior muscles of the head and neck.

Fig. 204.—Side View of Ligamentum Nuchæ.



In man it is rudimentary, and consists of elastic and white fibrous tissues. As seen in the horse, elephant, ox, and other mammiferous quadrupeds, it is a great and important elastic ligament, which even reaches along the dorsal part of the spinal column. In these animals it serves to support the head and neck, which otherwise from their own weight would hang down. Its rudimentary state in man is the direct consequence of his erect position.

The **interspinous ligaments** (fig. 205) are thin membranous structures which extend between the spines, and are connected with the ligamenta subflava in front, and the supraspinous ligament behind. The fibres pass obliquely from the root of one spine to the tip of the next; they thus decussate. They are best marked in the lumbar region, and are replaced by the well-developed *interspinales* muscles in the cervical region.

(e) THE LIGAMENTS CONNECTING THE TRANSVERSE PROCESSES WITH ONE ANOTHER

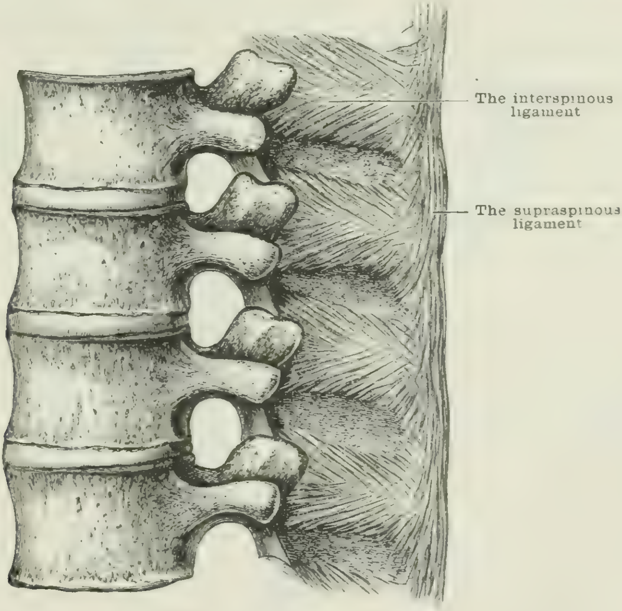
The **intertransverse ligaments** are barely worth the name; in the thoracic region they form small rounded bundles, and in the lumbar they are thin membranous bands, quite incapable of action as bonds of union. They consist of fibres passing between the apices of the transverse processes. In the cervical region they are replaced by the *intertransversales* muscles.

The **arterial supply** for the column comes from twigs of the vertebral, ascending pharyngeal, ascending cervical, superior and aortic intercostals, lumbar, iliolumbar, and lateral sacral.

The **nerve-supply** comes from the spinal nerves of each region.

Movements.—The spinal column is so formed of a number of bones and intervertebral discs as to serve many purposes. It is the axis of the skeleton; upon it the skull is supported; and with it the cavities of the trunk, and the limbs are connected. As a fixed column it is capable of bearing great weight; and, through the elastic intervertebral substances, of resisting and breaking the transmission of shocks. Moreover, it is flexible, and therefore capable of movement. Now, the range of movements of the column as a whole is very considerable; but the movements between any two vertebræ are slight, so that motions of the spine may take place without any change in the shape of the column, and without any marked disturbance in the relative positions of the vertebræ. It is about the pulpy part of the intervertebral discs, which form a central elastic pivot or ball, upon which the middle of the vertebræ rest, that these movements take place.

FIG. 205.—THE INTERSPINOUS AND SUPRASPINOUS LIGAMENTS IN THE LUMBAR REGION.



The amount of motion is everywhere limited by the common vertebral ligaments, but it depends partly upon the width of the bodies of the vertebræ, and partly upon the depth of the discs, so that in the loins, where the bodies are large and wide, and the discs very thick, free motion is permitted; in the cervical region, though the discs are thinner, yet, as the bodies are smaller, almost equally free motion is allowed. As the ball-like pulpy part of the intervertebral disc is the centre of movement of each vertebra, it is obvious that the motion would be of a rolling character in any direction but for the articular processes, which serve also to give steadiness to the column and to assist in bearing the superincumbent weight.

Were it not for these processes, the column, instead of being a stationary one, endowed with the capacity of movement by muscular agency, would be a tottering one, requiring muscles to steady it. The influence of the articular processes in limiting the direction of inclination will appear from a study of the movements in the three regions of the spine.

In the **neck**, the obliquity of the processes permits all movements, but is especially favourable for extension. Flexion is less free here than in the lumbar region, while extension is freer. Lateral flexion is more free in the neck than in any other region. Rotatory movements are also free in the neck, especially in the lower part. There is but slight movement of any sort between the axis and third cervical vertebra, owing to the shallow intervertebral disc and the great prolongation of the anterior lip of the inferior surface of the body of the axis, which checks forward flexion considerably.

In the **thoracic region**, especially near its middle, antero-posterior flexion and extension are very slight; and, as the concavity of the curve here is forwards, the flat and nearly vertical surfaces of the articular processes prevent anything like sliding in a curvilinear manner of the one set of processes over the sharp upper edges of the other, which would be necessary for forward flexion. A fair amount of lateral flexion would be permitted but for the impediment offered by the ribs; while the slightly outward inclination of the superior process, and inward inclination of the inferior, allow a little rotation, which is freer in the upper than in the lower part of the thoracic region.

In the **lumbar region**, extension and flexion are very free, especially between the third and fourth, and fourth and fifth vertebræ, where the lumbar curve is sharpest; lateral inclination is also very free between these same vertebræ. It has been stated that the shape and position of the articular processes of the lumbar and the lower two or three dorsal are such as to prevent any rotation in these regions; but, owing to the fact that the inferior articular processes are not tightly embraced by the superior, so that the two sets of articular processes are not in contact on both sides of the bodies at the same time, there is always some space in which horizontal motion can occur round an axis drawn through the central part of the bodies and intervertebral discs. Thus, the motions are most free in those regions of the column which have a convex curve forwards, due to the shape of the intervertebral discs, where there are no bony walls surrounding solid viscera, where the spinal canal is largest and its contents are less firmly attached, and where the pedicles and articular processes are more nearly on a transverse level with the posterior surface of the bodies of the vertebræ.

Nor must the uses of the ligamenta subflava be forgotten: these useful little structures (1) complete the roofing-in of the spinal canal, and yet at the same time permit an ever-changing variation in the width of the interlaminar spaces in flexion and extension; (2) they also restore the articulating surfaces to their normal position with regard to each other after movements of the column; (3) and by forming the inner portion of each capsular ligament they take the place of muscle, in preventing it from being nipped between the articular surfaces during movement.

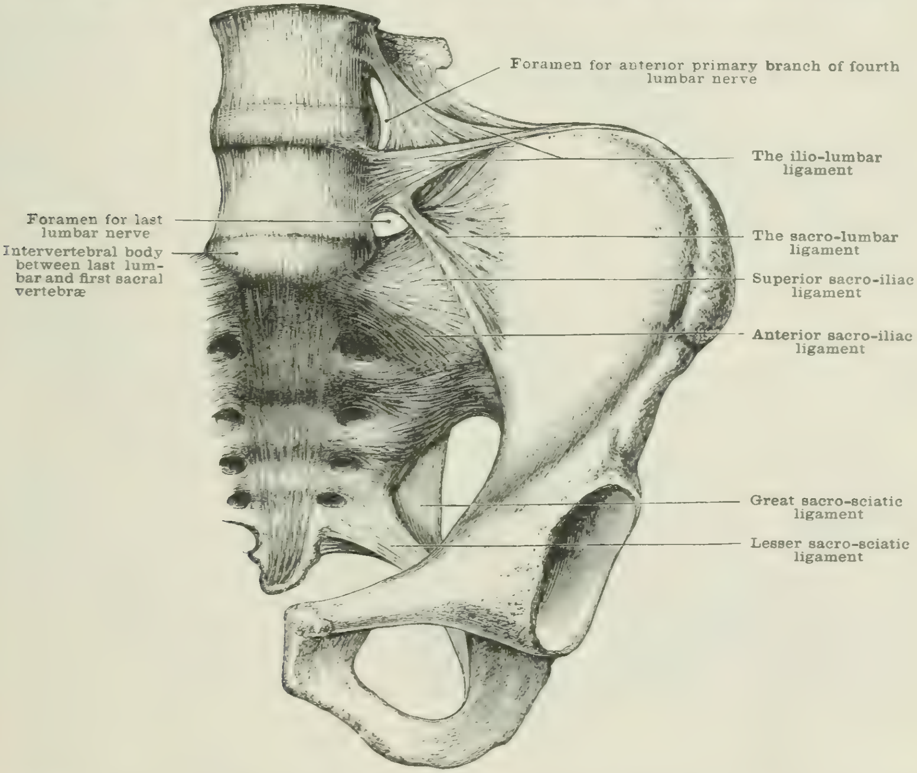
2. THE SACRO-VERTEBRAL ARTICULATIONS, OR THE ARTICULATIONS OF THE PELVIS WITH THE SPINE

(*a*) **Class.**—*Amphiarthrosis.*
(*b*) **Class.**—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

As in the intervertebral articulations, so in the union of the first portion of the sacrum with the last lumbar vertebra, there are two sets of joints—viz. (*a*) an amphiarthrodial one, between the bodies and intervertebral disc; and (*b*) a pair of arthrodial joints, between the articular processes. The union is effected by the following ligaments, which are common to the spinal column:—(i) anterior, and (ii) posterior, common; (iii) lateral or short vertebral; (iv) capsular; (v) ligamentum subflavum; (vi) supra- and (vii) interspinous ligaments. Two special accessory ligaments on either side, viz. the sacro-lumbar and the ilio-lumbar, connect the pelvis with the fourth and fifth lumbar vertebræ.

The **sacro-lumbar ligament** (fig. 206) is strong, and triangular in shape. Its apex is above and internal, being attached to the whole of the lower border and front surface of the transverse process of the fifth lumbar vertebra, as well as to the pedicle and body. It is intimately blended with the *ilio-lumbar ligament*. Below, it has a wide fan-shaped attachment, extending from the edge of the ilio-lumbar ligament forwards to the brim of the true pelvis; blending with the periosteum on the base of the sacrum and in the iliac fossa, and with the superior sacro-iliac ligament. By its sharp internal border it limits externally the foramen for the *last lumbar nerve*. It is pierced by two large foramina, which transmit arteries to the sacro-iliac synchondrosis. This ligament is in series with the intertransverse ligaments of the spinal column.

FIG. 206.—ANTERIOR VIEW OF THE LIGAMENTS BETWEEN THE SPINE AND PELVIS.


Foramen for anterior primary branch of fourth lumbar nerve
The ilio-lumbar ligament
Foramen for last lumbar nerve
Intervertebral body between last lumbar and first sacral vertebræ
The sacro-lumbar ligament
Superior sacro-iliac ligament
Anterior sacro-iliac ligament
Great sacro-sciatic ligament
Lesser sacro-sciatic ligament

The **ilio-lumbar ligament** (fig. 206) is a strong, dense, triangular ligament, which springs from the front surface of the transverse process of the fifth lumbar vertebra as far as the body, by a strong fasciculus from the posterior surface of the process near the tip, and also from the front surface and lower edge of the transverse process and pedicle of the fourth lumbar vertebra, as far inwards as the body. *Between these two lumbar vertebræ it is inseparable from the intertransverse ligament.* At its origin from the transverse process of the fifth lumbar vertebra, it is closely interwoven with the sacro-lumbar ligament, and some of its fibres spread downwards on to the body of the fifth vertebra, while others ascend to the disc above.

At the pelvis it is attached to the inner lip of the crest of the ilium for about two inches (5 cm.). The highest fibres at the spine form the upper edge of the ligament at the pelvis, those which come from the posterior portion of the transverse process of the fifth lumbar vertebra forming the lower, while the fibres from the front of the same process pass nearly horizontally outwards.

Near the spine the surfaces look directly backwards and forwards, but at the ilium, the ligament gets somewhat twisted, so that the posterior surface looks a little upwards, and the anterior looks a little downwards.

The anterior surface forms part of the posterior boundary of the false pelvis, and overlies the upper part of the posterior sacro-iliac ligament; the posterior surface forms part of the floor of the spinal groove, and gives origin to the *multifidus spinæ* muscle. Of the borders, the upper is oblique, has the anterior lamella of the lumbar fascia attached to it, and gives origin to the *quadratus lumborum;* the lower is horizontal, and is adjacent to the upper edge of the sacro-lumbar ligament; while the inner is crescentic, and forms the outer boundary of a foramen through which the *fourth lumbar* nerve passes.

The **arterial supply** is very free, and comes from the last lumbar, ilio-lumbar, and lateral sacral.

The **nerve-supply** is from the sympathetic, as well as from twigs from the fourth and fifth lumbar nerves.

Movements.—The angle formed by the sacrum with the spinal column is called the sacro-vertebral angle. The pelvic inclination does not depend entirely upon this angle, but in great part upon the obliquity of the innominate bones to the sacrum, so that in males in whom the average pelvic obliquity is a little greater, the average sacro-vertebral angle is considerably less than in females.

The sacro-vertebral angle in the male shows that there is a greater and more sudden change in direction at the sacro-vertebral union than in the female. A part of this change in direction is due to the greater thickness in the anterior part of the intervertebral substance between the last lumbar vertebra and the sacrum. Owing to the greater thickness of the intervertebral disc here than elsewhere, the movements permitted at this joint are very free, being freer than those between any two lumbar vertebræ. As the diameter of the two contiguous bones is less antero-posteriorly than laterally, the forward and backward motions are much freer than the lateral ones. The backward and forward motions take place every time the sitting is exchanged for the standing position, and the standing for the sitting posture; in rising, the back is extended on the sacrum at the sacro-lumbar union; in sitting down it is flexed.

The articular processes provide for the gliding movement incidental to the extension, flexion, and lateral movements; they also allow some horizontal movement, necessary for the rotation of the spine on the pelvis, or pelvis on the spine. The inferior articular processes of the fifth differ considerably from the inferior processes in the rest of the lumbar vertebræ, and in direction they resemble somewhat those of the cervical vertebræ; while the superior articular processes of the sacrum differ in a similar degree from the superior processes of the lumbar vertebræ. This difference allows for the freer rotation which occurs at this joint.

The sacro-vertebral angle averages 117° in the male, and 130° in the female; while the pelvic inclination averages 155° in the male, and 150° in the female.

3. THE ARTICULATIONS OF THE PELVIS

This group may again be subdivided into—

(*a*) The **sacro-iliac.**
(*b*) The **sacro-coccygeal.**
(*c*) The **intercoccygeal.**
(*d*) The **symphysis pubis.**

(*a*) The Sacro-iliac Synchondrosis and Sacro-sciatic Ligaments

Class.—*Amphiarthrosis.*

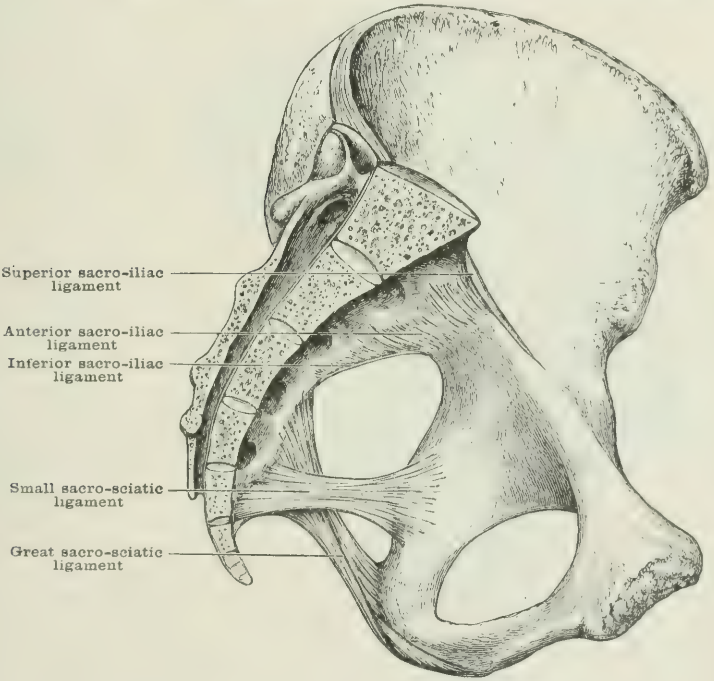
Like the symphysis pubis, the sacro-iliac synchondrosis is an amphiarthrodial joint, but it differs from it in having an interosseous ligament as well as an interosseous, or symphysial, cartilage. The bones which enter into the joint are the sacrum and ilium, and they are bound together by the following ligaments:—

Anterior sacro-iliac.
Posterior sacro-iliac.
Superior sacro-iliac.
Inferior sacro-iliac.
Interosseous.

The **anterior sacro-iliac ligament** (figs. 206 and 207) consists of well-marked glistening fibres which pass above into the superior, and below into the inferior, ligaments. It extends from the first three bones of the sacrum to the ilium between the brim of the true pelvis and the great sacro-sciatic notch, blending with the periosteum of the sacrum and ilium as it passes away from the united edges of the bones.

The **superior sacro-iliac ligament** (figs. 206 and 207) extends across the upper margins of the joint, from the base of the sacrum to the iliac fossa, being well marked along the brim of the pelvis, where it is thickened by some closely-packed fibres. Behind, it is far stronger, especially beneath the transverse process of the fifth lumbar vertebra. This ligament is connected with the strong sacro-lumbar ligament, which spreads outwards and forwards over the joint to reach the iliac fossa and ilio-pectineal line.

FIG. 207.—VERTICAL ANTERO-POSTERIOR SECTION OF THE PELVIS.


Superior sacro-iliac ligament
Anterior sacro-iliac ligament
Inferior sacro-iliac ligament
Small sacro-sciatic ligament
Great sacro-sciatic ligament

The **posterior sacro-iliac ligament** is of very great strength, extending between the back of the sacrum and the posterior two inches of the iliac crest, including the posterior superior spine. Strengthening the upper and back part of this fibrous expansion are some strong bundles of ligamentous fibres, which extend more or less transversely from the inner surface of the iliac crest: (i) to the articular process of the first sacral vertebra; (ii) to the bone between the articular process and the first sacral foramen; and (iii) to the articular tubercle of the second sacral vertebra, forming a ridge over the second sacral foramen under which the nerve passes; an oblique band often connects this last fasciculus with the articular process of the first sacral vertebra. Below this, the fibres pass downwards and inwards from the last inch of the iliac crest to the side of the sacrum external to the second and third posterior sacral foramina. To the outer edge of this ligament is attached the fascia covering the erector spinæ muscle.

The **inferior sacro-iliac ligament** (fig. 207) is covered behind by the upper end of the great sacro-sciatic ligament; it consists of strong fibres extending from the lateral border of the sacrum below the articular facet, to the posterior iliac spines; some of the fibres are attached to the deep surface of the ilium and join the interosseous ligament.

The **interosseous ligament** is the strongest of all, and consists of fibres of different lengths passing in various directions between the two bones. Immediately above the interspinous notch of the ilium the fibres of this ligament are very strong, and form an open network, in the interstices of which is a quantity of fat in which the articular vessels ramify.

The **ear-shaped cartilaginous plate**, which unites the bones firmly, is accurately applied to the auricular surfaces of the sacrum and ilium. It is about one-twelfth of an inch (2 mm.) thick in the centre, but becomes thinner towards the edges. Though closely adherent to the bones, it tears away from one entirely, or from both partially, on the application of violence, sometimes breaking irregularly so that the greater portion remains connected with one bone, leaving the other bone rough and bare. It is really one mass, and is only occasionally formed of two plates with a synovial cavity between them. Because of the occasional presence of a more or less extensive synovial cavity within the fibro-cartilage, and also of a synovial lining to the ligaments passing in front and behind the articulation, the term 'Diarthro-amphiarthrosis' has been given to this joint, and also to the symphysis pubis. Testut mentions certain folds of synovial membrane filling up gaps which here and there occur at margin of the fibro-cartilage, but I have not myself seen such.

The **great** or **posterior sacro-sciatic ligament** (figs. 206, 207 and 208) is attached above to the posterior extremity of the crest of the ilium and the external aspect of the posterior iliac spines. From this attachment some of its fibres pass downwards and backwards to be attached to the outer borders and posterior surfaces of the lower three sacral vertebræ and upper two segments of the coccyx; while others, after passing for a certain distance backwards, curve forwards and downwards to the ischium forming the anterior free margin of the ligament where it limits posteriorly the sacro-sciatic foramina. These fibres are joined by others which arise from the posterior surfaces of the lower three sacral vertebræ and upper pieces of the coccyx. At the ischium it is fixed to the inner border of the great tuberosity, and sends a thin sharp process upwards along the ramus of the ischium which is called the **falciform process** (fig. 208), and is a prolongation of the posterior edge of the ligament. A great many fibres pass on directly into the tendon of the biceps muscle, so that traction on this muscle braces up the whole ligament, and the coccyx is thus made to move on the sacrum. The ligament may not unfairly be described as a tendinous expansion of the muscle, whereby its action is extended and a more advantageous leverage given. It is broad and flat at its attached ends, but narrower and thicker in the centre, looking like two triangular expansions joined by a flat band, the larger triangle being at the ilium, and the smaller at the ischium. The fibres of the ligament are twisted upon its axis at the narrow part, so that some of the superior fibres pass to the lower border.

The posterior surface gives origin to the *gluteus maximus* muscle, and on it ramify the loops from the posterior branches of the sacral nerves; its anterior surface is closely connected at its origin with the small sacro-sciatic ligament, and some fibres of the *pyriformis* muscle arise from it; below, the *obturator internus* passes out of the pelvis under its cover, and the *internal pudic vessels and nerve* pass in. At the ilium, its posterior edge is continuous with the vertebral aponeurosis; while to the anterior edge is attached the thick fascia covering the gluteus medius. The obturator fascia is attached to its falciform edge. It is pierced by the *coccygeal branches of the sciatic*, and a branch from the *fourth sacral nerve*.

The **small sacro-sciatic ligament** (figs. 206, 207 and 208) is triangular and thin, springing by a broad base from the lateral border of the sacrum and coccyx, from the front of the sacrum both above and below the level of the fourth sacral foramen, and from the coccyx nearly as far as its tip. By its apex it is attached to the front surface and the borders of the ischial spine as far outwards as its base. Its fibres decussate so that the lower ones at the coccyx become the highest at the ischial spine; muscular fibres are often seen intermingled with the ligamentous.

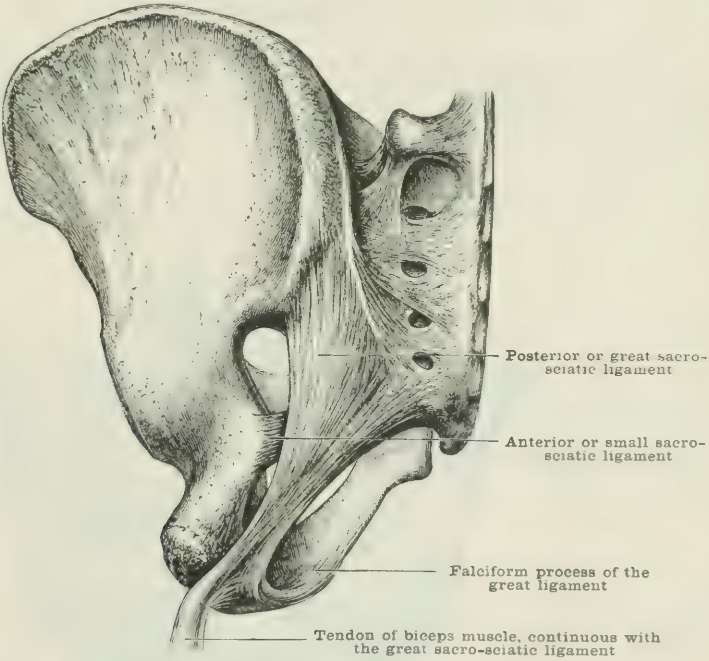
It is situated in front of the great sacro-sciatic ligament, with which it is closely connected at the sacrum, and separates the greater from the lesser sacro-sciatic foramen. Its front surface gives attachment to the *coccygeus* muscle, which overlies it. Behind, it is connected with, and hidden by, the great sacro-sciatic ligament, so that only the outer inch or less (2 cm.) and a small part of its attachment to the coccyx, can be seen; the *internal pudic* nerve also passes over the posterior surface.

The **arterial supply** comes from the gluteal, ilio-lumbar, and lateral sacral.

The **nerve-supply** is from the superior gluteal, sacral plexus, and external twigs of the posterior divisions of the first and second sacral nerves.

The movements.—It is quite clear, from the nature of the osseous surfaces, from the wedge-shape of the sacrum, and the manner in which it is locked in between the hip-bones, as well as from the amphiarthrodial character of the articulation, that there can be no movement at the sacro-iliac joint. While the joint serves the useful purpose of breaking shocks, the cartilage is too thin and too firmly fixed to the bones to allow even of appreciable yielding, such as occurs upon the intervertebral discs.

FIG. 208.—SACRO-SCIATIC LIGAMENTS. (Posterior view.)


Posterior or great sacro-sciatic ligament
Anterior or small sacro-sciatic ligament
Falciform process of the great ligament
Tendon of biceps muscle, continuous with the great sacro-sciatic ligament

The double wedge-shape of the sacrum, with its broader surface at the base and in front, prevents dislocation from forces acting from above downwards, and from before backwards.

The sinuous character of the opposed surfaces of the sacrum and ilium, the forward and inward direction of the fibres of the posterior sacro-sciatic ligament which pass from ilium to sacrum, as well as the ilio-lumbar and sacro-lumbar ligaments, prevent forward displacement of the base of the sacrum; while the sacro-sciatic ligaments prevent the tilting backwards of its apex. Thus rotation forwards is entirely prevented.

The shape of the sacrum prevents its downward displacement, while the weight of the spine and the ligaments, which fasten the sacrum to the ilium, are sufficient to check its upward displacement.

The anterior and downward displacements of the sacrum are prevented by the interosseous and posterior sacro-sciatic ligaments, which pass from the ilia to the sacrum, and suspend the latter, acting somewhat in the same manner as the chains of a suspension bridge. They also bind the two bones more tightly together: the greater the pressure, the tighter the union. The suspension bridge arrangement of the sacro-iliac synchondrosis is admirably adapted to give strength to the pelvis.

(*b*) THE SACRO-COCCYGEAL ARTICULATION

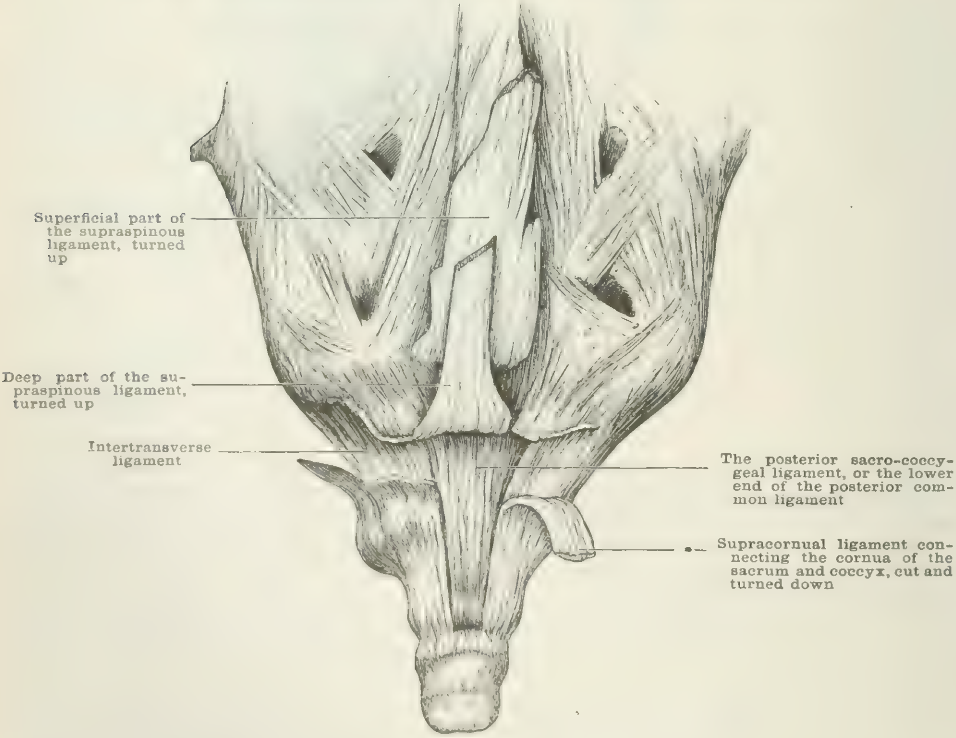
Class.—*Amphiarthrosis.*

The last piece of the sacrum and first piece of the coccyx enter into this union, and are bound together by the following ligaments:—

Anterior sacro-coccygeal.
Posterior sacro-coccygeal.
Supracornual.
Intertransverse.
Intervertebral substance.

The **intervertebral substance** is a small oval disc, three-quarters of an inch (about 2 cm.) wide, and a little less from before backwards, closely connected with the surrounding ligaments. It resembles the other discs in structure, but is softer and more jelly-like, though the laminæ of the fibrous portion are well marked.

FIG. 209.—LIGAMENTS CONNECTING SACRUM AND COCCYX POSTERIORLY.


Superficial part of the supraspinous ligament, turned up
Deep part of the supraspinous ligament, turned up
Intertransverse ligament
The posterior sacro-coccygeal ligament, or the lower end of the posterior common ligament
Supracornual ligament connecting the cornua of the sacrum and coccyx, cut and turned down

The **anterior sacro-coccygeal ligament** is a prolongation of the glistening fibrous structure on the front of the sacrum. It is really the lower extremity of the anterior common ligament, which is thicker over this joint than over the central part of either of the bones.

The **posterior sacro-coccygeal ligament** (fig. 209) is a direct continuation of the posterior common ligament of the column, consisting of a narrow band of closely packed fibres, which become blended at the lower border of the first segment of the coccyx with the filum terminale and supracornual ligament.

The **supracornual ligament** (fig. 209) is the prolongation of the supraspinous, which becomes inseparably blended with the aponeurosis of the *erector spinæ* opposite the laminæ of the third sacral vertebra, and is thus prolonged downwards upon the back of the coccyx, passing over and roofing in the lower end of the spinal canal where the laminæ are deficient. The median fibres (the **supraspinous ligament**) extend over the back of the coccyx to its tip, blending with the posterior sacro-coccygeal ligament and filum terminale; the deeper fibres run across from the stunted laminæ on one side to the next below on the opposite side, and from the sacral cornua on one side to the coccygeal on the opposite, some passing between the two cornua of the same side, and bridging the aperture through which the fifth sacral nerve passes. Its posterior surface gives origin to the *gluteus maximus* muscle.

The **intertransverse ligament** (fig. 209) is merely a quantity of fibrous tissue which passes from the transverse process of the coccyx to the lateral edge of the sacrum below its angle. It is connected with the sacro-sciatic ligaments at their attachments, and the *fifth sacral* nerve escapes behind it. It is perforated by twigs from the lateral sacral artery and the coccygeal nerve.

The **arterial supply** is from the lateral sacral and sacro-median arteries.

The **nerves** come from the fourth and fifth sacral and coccygeal nerves.

The **movements** permitted at this joint are of a simple forward and backward, or hinge-like character. In the act of defecation, the bone is pushed back by the fæcal mass, and, in parturition, by the fœtus; but this backward movement is controlled by the upward and forward pull of the levator ani and coccygeus. The external sphincter also tends to pull the coccyx forwards.

(c) INTERCOCCYGEAL JOINTS

The several segments of the coccyx are held together by the anterior and posterior common ligaments, which completely cover the bony nodules on their anterior and posterior aspects. Laterally, the sacro-sciatic ligaments, being attached to nearly the whole length of the coccyx, serve to connect them. Between the first and second pieces of the coccyx there is a very perfect amphiarthrodial joint, with a well-marked intervertebral substance.

(d) THE SYMPHYSIS PUBIS

Class.—*Amphiarthrosis.*

The bones entering into this joint are the pubic portions of the hip-bones. This joint is shorter and broader in the female than in the male. The ligaments, which completely surround the articulation, are:—

Superior.	Anterior.
Inferior.	Posterior.

Interosseous cartilage.

The **superior ligament** (figs. 210 and 211) is a well-marked stratum of yellowish fibres which extends outwards along the crest of the pubes on each side, blending in the middle line with the interosseous cartilage. It is continuous in front with the deep transverse fibres of the anterior ligament, and behind with the posterior ligament. It gives origin to the *rectus abdominis* tendon.

The **posterior ligament** (fig. 212) is slight, and, excepting above and below, consists of little more than thickened periosteum. Near the upper part is a band of strong fibres, reaching the whole width of the pubic bones, and continuous with the thickened periosteal fibres along the ilio-pectineal line. Below, many of the upper and superficial fibres of the infrapubic ligament ascend over the back of the joint, and interlace across the median line with fibres from the opposite side nearly as high as the middle of the symphysis.

The **anterior ligament** (figs. 210 and 211) is thick and strong, and is closely connected with the fascial covering of the muscles arising from the body of the pubes. It consists of several strata of thick decussating fibres of different degrees of obliquity, the superficial being the most oblique, and extending lowest over the joint. The most superficial descending fibres extend from the upper border of the pubis, cross others from the opposite side about the middle of the symphysis, and are attached to the ramus of the opposite bone. The most superficial ascending fibres come from the infrapubic ligament, arch upwards, and decussate with other fibres across the middle line, and are lost on the opposite side beneath the descending set. There is another deeper set of descending fibres which arise below the angle, but do not descend so far as the superficial; and a deeper set of ascending, which decussate, and reach higher than the superficial set, and are connected with the infrapubic ligament. Some few transverse fibres pass from side to side, especially above and below the points of decussation.

FIG. 210.—ANTERIOR VIEW OF THE SYMPHYSIS PUBIS (MALE), SHOWING THE DECUSSATION OF THE FIBRES OF THE ANTERIOR LIGAMENT.

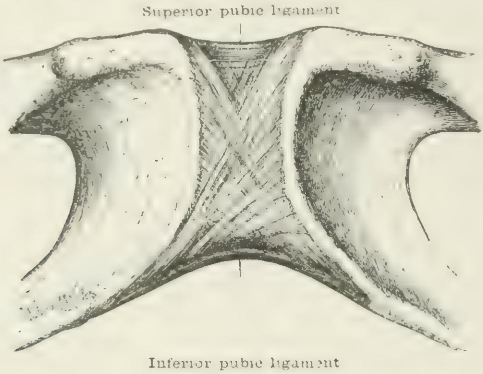
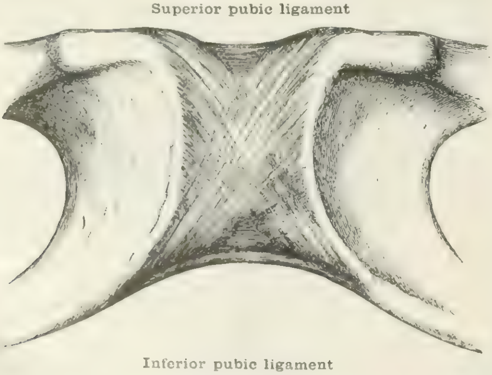


FIG. 211.—ANTERIOR VIEW OF THE SYMPHYSIS PUBIS (FEMALE), SHOWING GREATER WIDTH BETWEEN THE BONES.



The **inferior** or **infrapubic ligament** (figs. 210, 211 and 212) is a thick, arch-like band of closely packed fibres which fills up the angle between the pubic rami, and forms a smooth, rounded summit to the pubic arch. On section, it is yellowish in colour and three-eighths of an inch (1 cm.) thick in the middle line; it is inseparably connected with the interosseous cartilage. Both on the front and back aspects of the joint it gives off decussating fibres, which, by their interlacement over the anterior and posterior ligaments of the symphysis, add very materially to its security. In fact, the ligament may be said to split superiorly into two layers, one passing over the front, and the other over the back of the articulation. It is sometimes known as the **ligamentum arcuatum.**

The **interosseous fibro-cartilage** varies in thickness in different subjects, but is thicker in the female than in the male. It is thicker in front than behind, and projects beyond the edges of the bones, especially posteriorly (see fig. 212), blending intimately with the ligaments at its margins. It is sometimes uninterruptedly woven throughout, but at others has an elongated narrow fissure, partially dividing the cartilage into two plates, with a little fluid in the interspace (fig. 213). This is situated towards the upper and posterior aspects, but does not usually reach either; it generally extends about half the length of the cartilage. When this cavity is large, especially if it reaches or approaches very near to the circumference of the cartilage (which, however, it very rarely does), it is thought by some anatomists that it more nearly resembles a diarthrodial than an amphiarthrodial joint, and it is then classed with the sacro-iliac joint under similar conditions, as 'diarthro-amphiarthrosis.' The interosseous cartilage is intimately adherent to the rough osseous surface of the bone, which is ridged to give it a firmer attachment; and, on forcing the bones apart, it does not frequently split into two plates, but is torn from the bone on one side or the other.

FIG. 212.—POSTERIOR VIEW OF THE SYMPHYSIS PUBIS, SHOWING THE BACKWARD PROJECTION OF THE SYMPHYSIAL SUBSTANCE AND THE DECUSSATION OF THE FIBRES FROM THE INFERIOR PUBIC LIGAMENT.

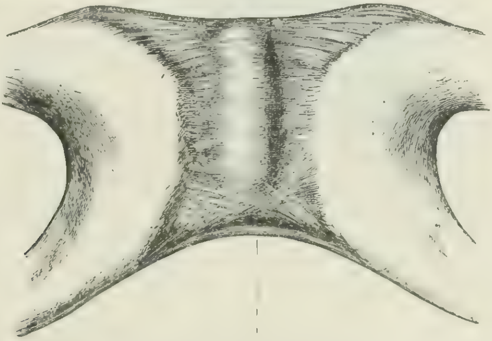
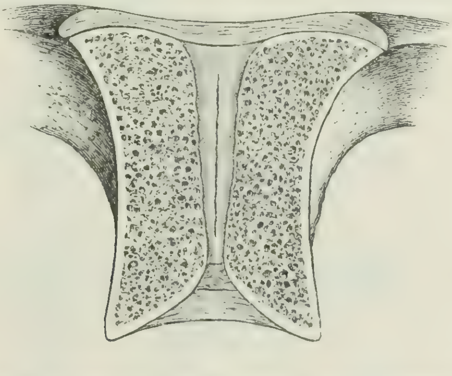


FIG. 213.—SECTION OF SYMPHYSIS TO SHOW THE SYNOVIAL CAVITY.



The **arterial supply** is from twigs of the internal pudic, pubic branches of the obturator and epigastric, and ascending branches of the internal circumflex and superficial external pudic.

The **nerve-supply** has not been satisfactorily made out, but it probably comes, in part from the internal pudic and in part from the ilio-hypogastric and ilio-inguinal.

The **movements** amount only to a slight yielding of the cartilage; neither muscular force nor extrinsic forces produce any appreciable movement in the ordinary condition. Occasionally, as the result of child-bearing, the joint becomes unnaturally loose, and then walking and standing are painfully unsteady. It is known that, during pregnancy and parturition, the symphysial cartilage becomes softer and more vascular, so as to permit the temporary enlargement of the pelvis; but it must be remembered that the fibres of the oblique muscles decussate, and thus, during labour, while they force the head of the fœtus down, they strengthen the joint by bracing the bones more tightly together.

4. THE ARTICULATIONS OF THE RIBS WITH THE VERTEBRÆ

These consist of two sets, viz.:—

(*a*) The **costo-central**: i.e. the articulation of the head of the rib with the vertebræ.

(*b*) The **costo-transverse,** or the articulation of the tubercle (of each of the first ten ribs) with the transverse process of the lower of the two vertebræ, with which the head of the rib articulates: i.e. the one bearing its own number, as the first rib with the first thoracic vertebra, the second rib with the second thoracic vertebra, and so on.

(*a*) THE COSTO-CENTRAL ARTICULATION

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

It is a very perfect joint, into the formation of which the head of the rib and two vertebræ, with the intervertebral disc between them, enter. In the case of the first, tenth, eleventh, and twelfth ribs, it is formed by the head of the rib articulating with a single vertebra.

The **ligaments** are:—

Capsular. Interarticular.
Stellate or anterior costo-central.

The **capsular ligament** (fig. 214) consists of short, strong, woolly fibres, completely surrounding the joint, which are attached to the bones and intervertebral substances, a little beyond their articular margins. At its upper part it reaches through the intervertebral foramen towards the back of the bodies of the vertebræ, being strengthened here by fibres which at intervals connect the anterior with the posterior common ligaments. The lower fibres extend downwards nearly to the demi-facet of the rib below; behind, it is continuous with the middle costo-transverse ligament, and in front is overlaid by the stellate.

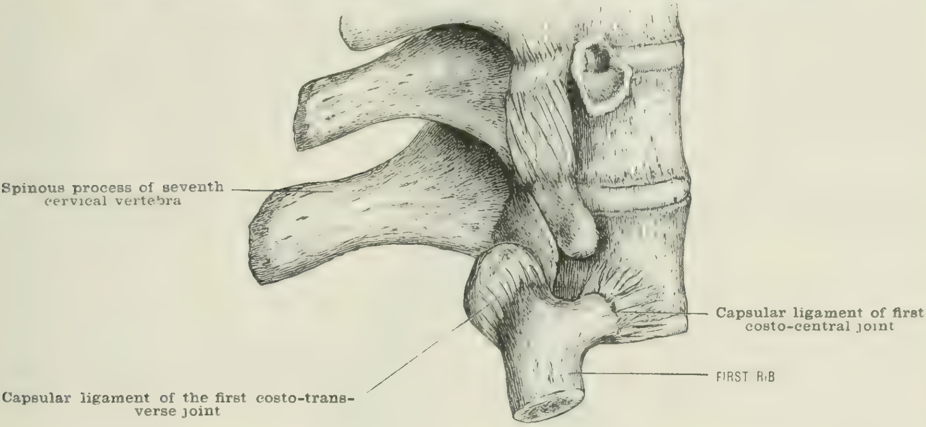
The **interarticular ligament** (fig. 215) consists of short, strong fibres, closely interwoven with the outermost ring of the intervertebral disc, and attached to the transverse ridge separating the articular facets on the head of the rib. It completely divides the articulations into two parts, but does not brace the rib tightly to the spine, being loose enough to allow a moderate amount of rotation on its own axis. There is no interarticular ligament in the costo-vertebral joints of the first, tenth, eleventh, and twelfth ribs.

The **anterior** costo-central or **stellate ligament** (figs. 215 and 216) is the most striking of all, and consists of bright, pearly-white fibres attached to the anterior surface, and upper and lower borders of the neck of the rib, a little way beyond the articular facet; from this they radiate upwards, forwards, and downwards, so as to form a continuous layer of distinct and sharply defined fibres. The middle fibres run straight forward to be attached to the intevertebral disc; the upper ascend to the lower half of the lateral surface of the vertebra above, and the lower descend to the upper half of the vertebra below.

The stellate ligament is overlapped at the spine by the short vertebral ligaments.

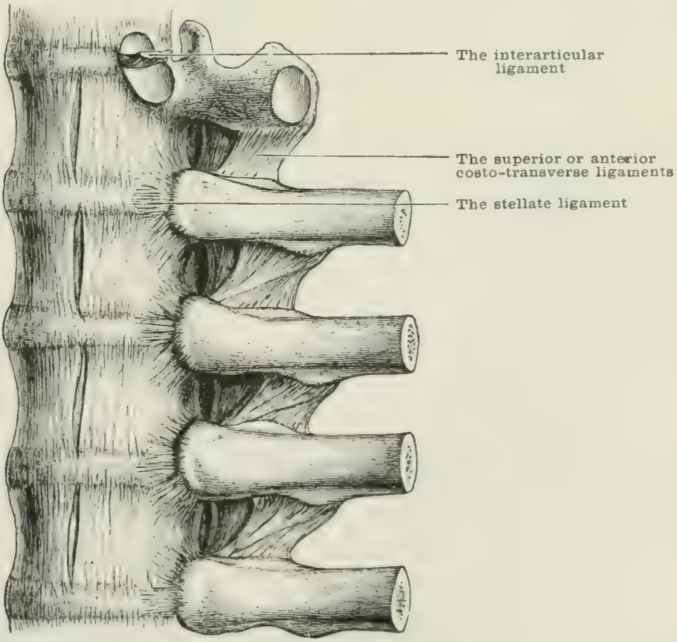
In the case of the first, tenth, eleventh, and twelfth ribs, each of which articulates with one vertebra, the ligament is not quite so distinctly stellate, but even in these the ascending fibres reach the vertebra above that with which the rib articulates.

Fig. 214.—The Capsular Ligaments of the Costo-vertebral Joints.


Spinous process of seventh cervical vertebra
Capsular ligament of first costo-central joint
FIRST RIB
Capsular ligament of the first costo-transverse joint

The **synovial membranes** (fig. 216) consist of two closed sacs which do not communicate: one above, and the other below the interarticular ligament. In the case of the first, tenth, eleventh, and twelfth articulations, there is but one synovial membrane, as these joints have no interarticular ligament.

Fig. 215.—Showing the Anterior Common Ligament of the Spine, and the Connection of the Ribs with the Vertebræ.


The interarticular ligament
The superior or anterior costo-transverse ligaments
The stellate ligament

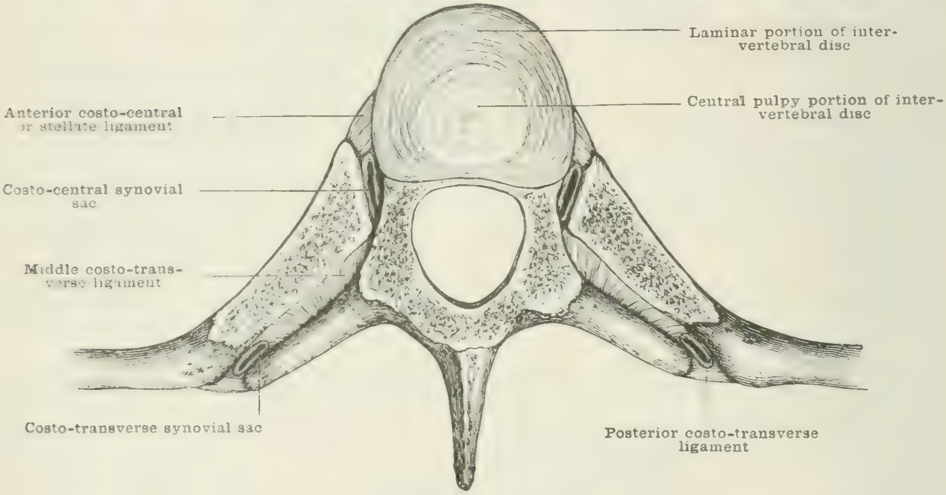
The **arterial supply** is from the intercostal arteries, the twigs piercing the stellate and capsular ligaments.

The **nerve-supply** comes from the anterior primary branches of the intercostal nerves.

These joints approach most nearly in their movements to the condylarthroses.

The **movements** are ginglymoid in character, consisting of a slight degree of elevation and depression around an obliquely horizontal axis corresponding with the interarticular ligament; there is also a slight amount of forward and backward gliding; and a slight degree of screwing or rotatory movement is also possible. There is a considerable difference in the degree of mobility of the different ribs, for while the first rib is almost immobile except in a very deep inspiration, the mobility of the others increases from the second to the last; the two floating ribs being the most mobile of all. The head of the rib is the most fixed point of the costal arch, and upon it the whole arch rotates; the interarticular ligament allows only a very limited amount of flexion and extension (i.e. elevation and depression), and of gliding. Gliding is checked by the stellate ligament.

FIG. 216.—HORIZONTAL SECTION THROUGH THE INTERVERTEBRAL DISC AND RIBS.


Laminar portion of intervertebral disc
Anterior costo-central or stellate ligament
Central pulpy portion of intervertebral disc
Costo-central synovial sac
Middle costo-transverse ligament
Costo-transverse synovial sac
Posterior costo-transverse ligament

In inspiration, the rib is elevated, and glides forwards in its socket, too great elevation being checked not only by the ligaments, but also by the overhanging upper edge of the cavity itself. In expiration, the rib is depressed, and glides backwards in its cavity.

(b) THE COSTO-TRANSVERSE ARTICULATION

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

This joint is formed by the tubercle of the rib articulating with the anterior part of the tip of the transverse process. The eleventh and twelfth ribs are devoid of these joints, for the tubercles of these ribs are absent, and the transverse processes of the eleventh and twelfth thoracic vertebræ are rudimentary.

The ligaments of the union are:—

Capsular.
Middle costo-transverse.
Superior costo-transverse.
Posterior costo-transverse.

The **capsular ligament** (figs. 214 and 216) forms a thin, loose, fibrous envelope to the synovial membrane. Its fibres are attached to the bones just beyond the articular margins, and are thickest below, where they are not strengthened by any other structure. It is connected on the inner side with the middle, above with the superior, and on the outer side with the posterior costo-transverse ligaments. The **eleventh** and **twelfth ribs** are unprovided with a capsule.

The **middle costo-transverse,** or **interosseous ligament** (fig. 216), consists of short fibres passing between the back of the neck of the rib and front of the transverse process, with which the tubercle articulates. It extends from the capsule of the central costo-vertebral joint to that of the costo-transverse. It is best seen on horizontal section through the bones. In the **eleventh** and **twelfth** ribs this ligament is rudimentary.

The **posterior costo-transverse ligament** (fig. 216) is a short but thick, strong, and broad ligament, which extends outwards and upwards from the extremity of the transverse process to the non-articular surface of the tubercle of the corresponding rib. The **eleventh** and **twelfth** ribs have no posterior ligament.

The **superior costo-transverse ligament** (fig. 215) is a strong, broad band of fibres which ascends outwards from the **crest** on the upper border of the neck of the rib, to the lower border of the transverse process above. A few scattered posterior fibres pass upwards and inwards from the neck to the transverse process. It is best seen from the front. Its inner border bounds the foramen through which the posterior branches of the intercostal vessels and nerves pass. To the external border is attached the thin aponeurosis covering the *external intercostals*. Its anterior surface is in relation with the intercostal vessels and nerve; the posterior with the *longissimus dorsi*. The **first** rib has no superior costo-transverse ligament.

The **synovial membrane** (fig. 216) is a single sac.

The **arterial** and **nerve supplies** come from the posterior branches of the intercostal arteries and nerves.

The **movements** which take place at these joints are limited to a gliding of the tubercle of the rib upon the transverse process. The exact position of the facet on the transverse process varies slightly from above downwards, being placed higher on the processes of the lower vertebræ. The plane of movement in most of the costo-transverse joints is inclined upwards and backwards in inspiration, and downwards and forwards in expiration. The point round which these movements occur is the head of the rib, so that the tubercle of the rib glides upon the transverse process in the circumference of a circle, the centre of which is at the costo-central joint.

5. THE ARTICULATIONS AT THE FRONT OF THE THORAX

These may be divided into four sets, viz.:—

(*a*) The **intersternal joints,** or the union of the several parts of the sternum with one another.

(*b*) The **costo-chondral joints,** or the union of the ribs with their costal cartilages.

(*c*) The **chondro-sternal articulations,** or the junction of the costal cartilages with the sternum.

(*d*) The **interchondral joints,** or the union of five costal cartilages (sixth, seventh, eighth, ninth, and tenth) with one another.

(*a*) THE INTERSTERNAL JOINTS, OR THE UNION OF THE SEGMENTS OF THE STERNUM WITH ONE ANOTHER

The sternum being composed, in the adult, of three distinct pieces,—the manubrium, the gladiolus or body, and the xiphoid,—has two articulations, viz., the Superior, which unites the manubrium with the gladiolus, and the Inferior, which unites the gladiolus with the xiphoid.

1. The Superior Intersternal Articulation.

Class.—*Amphiarthrosis.*

The lower border of the manubrium and the upper border of the body of the sternum present oval-shaped, flat surfaces, with their long axes transverse, and covered with a thin layer of hyaline cartilage. An **interosseous fibro-cartilage** is interposed between the bony surfaces: it corresponds exactly in shape and intimately adheres to them. At each lateral border this fibro-cartilage enters into the formation of the second chondro-sternal articulation (fig. 217). In consistence it varies, being in some cases uniform throughout, in others softer in the centre than at the circumference, and in others again an oval-shaped synovial cavity is found towards its anterior part. When such a cavity exists in the fibro-cartilage this joint has a remote resemblance to the diarthrodes, and is classed, with the sacro-iliac joint and the symphysis pubis under similar conditions, as 'diarthro-amphiarthrosis.'

The periosteum passes uninterruptedly over the joint from one segment of the sternum to the other, forming a kind of capsular ligament. This capsule is strengthened, especially on its posterior aspect, by longitudinal ligamentous fibres as well as by the radiating and decussating fibres of the chondro-sternal ligaments.

In some instances the fibro-cartilage is replaced by short bundles of fibrous tissue which unite the cartilage-coated articular bony surfaces.

2. The Inferior Intersternal Articulation.

Class.—*Synarthrosis.*

The gladiolus is joined to the xiphoid cartilage by a thick investing membrane, by anterior and posterior longitudinal fibres, and by radiating fibres of the sixth and seventh chondro-sternal ligaments. The **chondro-xiphoid ligament** also connects the xiphoid with the anterior surface of the sixth and seventh costal cartilages, and thus indirectly with the gladiolus; and some fine fibro-areolar tissue also connects the xiphoid with the back of the seventh costal cartilage.

The junction of the xiphoid with the sternum is on a level somewhat posterior to the junction of the seventh costal cartilage with the sternum. The union is *synarthrodial*.

(*b*) THE COSTO-CHONDRAL JOINTS

Class.—*Synarthrosis.*

The extremity of the costal cartilage is received into a cup-shaped depression at the end of the rib, which is somewhat larger than the cartilage. The two are joined together by the continuity of the investing membranes, the periosteum of the rib being continuous with the perichondrium of the cartilage, much in the same way as the epiphyses of the bones are joined to their shafts.

(*c*) THE CHONDRO-STERNAL ARTICULATIONS

Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

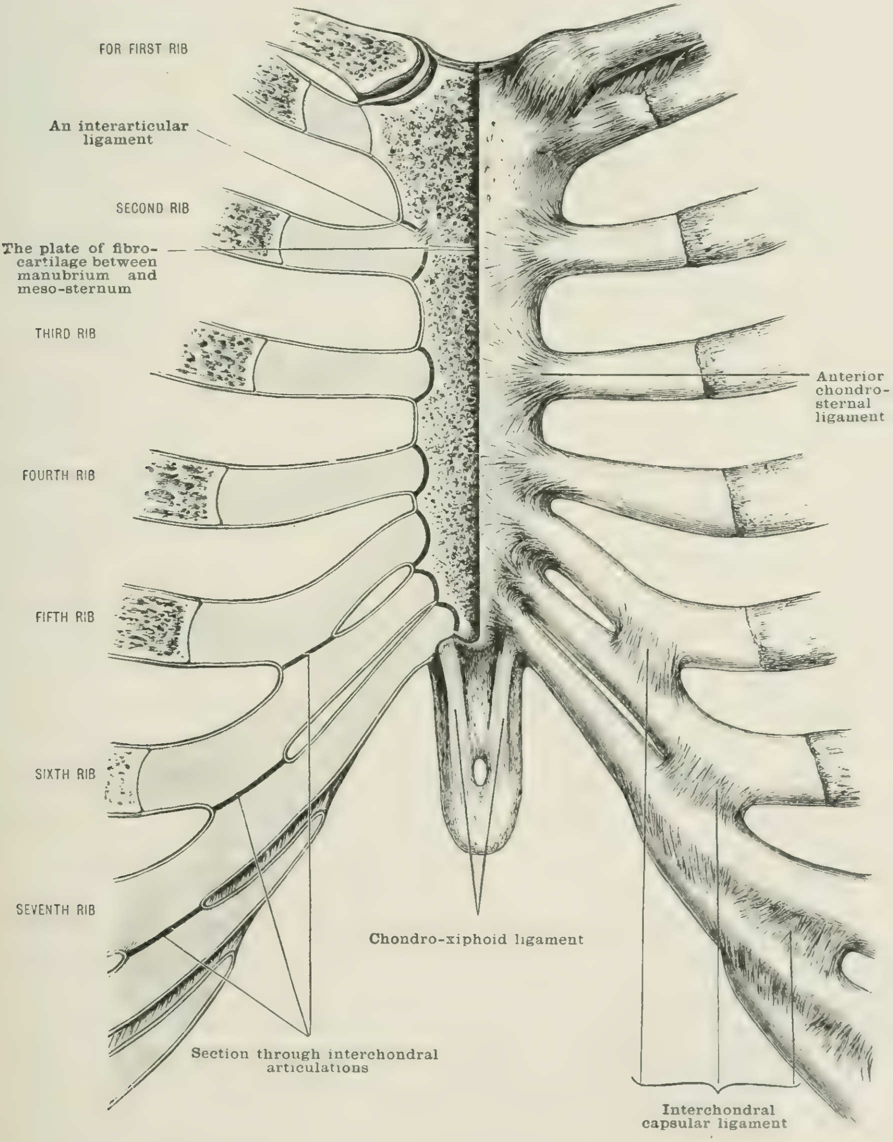
These articulations are between the lateral borders of the sternum and the ends of the costal cartilages. The union of the first rib with the sternum is *synarthrodial*, and therefore forms an exception to the others. From the second to the seventh inclusive, the articulations have the following ligaments, which together form a complete capsule:—

Anterior chondro-sternal.
Posterior chondro-sternal.
Superior chondro-sternal.
Inferior chondro-sternal.

The **anterior chondro-sternal ligament** (fig. 217) is a triangular band of strong fibres which cover the inner half-inch of the front of the costal cartilage, and radiate upwards and downwards upon the front of the sternum. Some of the fibres decussate across the middle line with fibres of the opposite ligament. At its upper and lower borders it is in contact with the superior and inferior ligaments respectively.

Fig. 217.—The Sternum.

(Left side, showing ligaments; right side, the synovial cavities.)


FOR FIRST RIB
An interarticular ligament
SECOND RIB
The plate of fibro-cartilage between manubrium and meso-sternum
THIRD RIB
Anterior chondro-sternal ligament
FOURTH RIB
FIFTH RIB
SIXTH RIB
SEVENTH RIB
Chondro-xiphoid ligament
Section through interchondral articulations
Interchondral capsular ligament

The **posterior chondro-sternal ligament** consists of little more than a thickening of the fibrous envelopes of the bone and cartilage, the joint being completed behind by a continuity of perichondrium with periosteum.

The **superior** and **inferior ligaments** are strong, well-marked bands, which pass from the upper and lower borders respectively of the costal cartilage to the lateral edges of the sternum. The sixth and seventh cartilages are so close that the superior ligament of the seventh is blended with the inferior of the sixth rib.

Deeper than the fibres of these ligaments are short fibres passing from the margins of the sternal facets to the edges of the facets on the cartilages; they are most distinct in the front and lower part of the joint, and may encroach so much upon the synovial cavity as to reduce it to a very small size, or almost obliterate it. This occurs mostly in the case of the sixth and seventh joints, especially the latter.

The **interarticular ligament** (fig. 217) is by no means constant, but is usually present in the second joint on one, if not on both sides of the same subject. It consists of a strong transverse bundle of fibres passing from the ridge on the facet on the cartilage to the symphysial substance between the manubrium and body; sometimes the upper part of the synovial cavity is partially or entirely obliterated by short, fine, ligamentous fibres.

The **chondro-xiphoid ligament** (fig. 217) is a strong flat band of fibres passing obliquely upwards and outwards from the front surface of the xiphoid cartilage to the anterior surface of the sternal end of the seventh costal cartilage, and most frequently to that of the sixth also.

Synovial membranes.—The union of the first cartilage with the sternum being synarthrodial, it has no synovial membrane; the second has usually two, separated by the interarticular ligament. The rest usually have one synovial membrane, which may occasionally be subdivided into two (fig. 217).

The **arterial supply** is derived from perforating branches of the internal mammary; and the **nerves** come from the anterior branches of the intercostals.

Movements.—Excepting the first, the chondro-sternal joints are ginglymoid, but the motion of which they are capable is very limited. It consists of a hinge-like action in two directions: first, there is a slight amount of elevation and depression which takes place round a transverse axis, and, secondly, there is some forward and backward movement round an obliquely vertical axis. In inspiration the cartilage is elevated, and the lowest part of its articular facet is pressed into the sternal socket, and the sternum is thrust forwards so that the upper and front edges of the articular surfaces separate a little; in expiration the reverse movement takes place. Thus the two extremities of the costal arches move in their respective sockets in opposite directions.

This difference results necessarily from the fact that the costal arch moves upon the vertebral column, and, having been elevated, it in its turn raises the sternum by pushing it upwards and forwards.

The chondro-xiphoid ligament tends to prevent the xiphoid cartilage from being drawn backwards by the action of the diaphragm.

(*d*) THE INTERCHONDRAL ARTICULATIONS

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

A little in front of the point where the costal cartilages bend upwards towards the median line, the sixth is united with the seventh, the seventh with the eighth, the eighth with the ninth, and the ninth with the tenth.

At this point, each of the cartilages from the sixth to the ninth inclusive is deeper than elsewhere, owing to the projection downwards from its lower edge of a broad blunt process, which comes into contact with the cartilage next below. Each of the apposed surfaces is smooth, and they are connected at their margins by ligamentous tissue, which forms a complete **capsule** for the articulation, and is lined by a synovial membrane (fig. 217). The largest of these cavities is between the seventh and eighth; those between the eighth and ninth, and ninth and tenth, are smaller, and are not free to play upon each other in the whole of their extent, being held together by ligamentous tissue at their anterior margins. Sometimes this fibrous tissue completely obliterates the synovial cavity.

The **arteries** are derived from the musculo-phrenic, and the **nerves** from the intercostals.

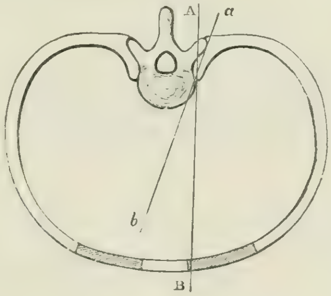
Movements.—By means of the costal cartilages and interchondral joints, strength with elasticity is given to the wall of the trunk at a part where the cartilages are the only firm structures in its composition: while a slight gliding movement is permitted between the costal cartilages themselves, which takes place round an axis corresponding to the long axis of the cartilages. By this means, the outward projection of the lower part of the thoracic wall is increased by deep inspiration.

MOVEMENTS OF THE THORAX AS A WHOLE

Before describing these movements as a whole, it must be premised that there are some few modifications in the movements of certain ribs resulting from their shape. Thus the first rib (and to a less extent the second also), which is flat on its upper and under surfaces, revolves on a transverse axis drawn through the costo-vertebral and costo-transverse joints. During inspiration and expiration, the anterior extremities of the first pair of costal arches play up and down, the tubercles and the heads of the ribs acting in a hinge-like manner, the latter having also a slight screwing motion. By this movement the anterior ends of the costal arches are simply raised or depressed, and the sternum pushed a little forwards: it may be likened to the movement of a pump-handle, as in fig. 218, *a*, *b*.

The movements of the other ribs, particularly in the mid-region of the thorax, are more complex, for, besides the elevation of the anterior extremities, the bodies and angles of the ribs rise nearly as much as the extremities themselves. In this movement the tubercles of the ribs glide upwards and backwards in inspiration, and downwards and forwards in expiration; and the movement may be likened to that of a bucket handle, as in fig. 218, A, B.

FIG. 218.—DIAGRAM OF AXIS OF RIB-MOVEMENT. (After Kirkes.)



During inspiration, the cavity of the thorax is increased in every direction. The **antero-posterior diameter** is increased by the thrusting forwards of the sternum, caused by the elevation of the costal cartilages and fore part of the ribs, whereby they are brought to nearly the same level as the heads of the ribs. The **transverse diameter** is increased: (i) Behind, by the elevation of the middle part of the ribs; for when at rest the mid-part of the rib is on a lower level than either the costo-vertebral or chondro-sternal articulations. Owing to this obliquity the transverse diameter is increased when the rib is raised, and the increase is proportionate to the degree of obliquity. (ii) By the eversion of the lower border of the costal arch, which rolls outwards as the arch is raised. (iii) The transverse diameter is increased in front by the abduction of the anterior extremity of the rib at the same time as it is elevated and thrust forwards.

The increase in the **vertical diameter** of the thorax is due to the elevation of the ribs, especially the upper ones, and the consequent widening of the intercostal spaces; but the chief increase in this direction is due to the descent of the diaphragm.

The greatest increase both in the antero-posterior and transverse diameters takes place where the ribs are longest, most oblique, and most curved at their angles, and where the bulkiest part of the lung is enclosed. This is on a level with the sixth, seventh, and eighth ribs.

At the lower part of the thorax, where the ribs have no relation to the lungs, and do not affect respiration directly by their movements, it is important that the costal arches should be thrown well outwards in order to counteract the compression of the abdominal viscera by the contraction of the diaphragm.

By widening and steadying the lower part of the thorax during inspiration, the attachments of the muscular fibres of the diaphragm are widened, and their power increased.

THE ARTICULATIONS OF THE UPPER EXTREMITY

The articulations of the upper extremity are the following:—

1. The **sterno-costo-clavicular.**
2. The **scapulo-clavicular union.**
3. The **shoulder-joint.**
4. The **elbow-joint.**
5. The **radio-ulnar union.**
6. The **radio-carpal** or **wrist-joint.**
7. The **carpal joints.**
8. The **carpo-metacarpal joints.**
9. The **intermetacarpal joints.**
10. The **metacarpo-phalangeal joints.**
11. The **interphalangeal joints.**

1. THE STERNO-COSTO-CLAVICULAR ARTICULATION

Class.—*Diarthrosis.* **Subdivision.**—*Saddle-shaped Arthrodia.*

At this joint the large inner end of the clavicle is united to the superior angle of the manubrium sterni, the first costal cartilage also assisting to support the clavicle. It is the only joint between the upper extremity and the trunk, and takes part in all the movements of the upper limb. Looking at the bones, one would say that they were in no way adapted to articulate with one another, and yet they assist in constructing a joint of great security, strength, and importance. The bones are nowhere in actual contact, being completely separated by an interarticular cartilage. The interval between the joints of the two sides varies from one inch to an inch and a half (2·5–4 cm.). The ligaments of this joint are:—

(1) Capsular.
(2) Interclavicular.
(3) Interarticular fibro-cartilage.
(4) Rhomboid or costo-clavicular.

The **capsular ligament** (figs. 219 and 220) consists of fibres, having varying directions and being of various strength and thickness, which completely surround the articulation, and are firmly connected with the edges of the interarticular fibro-cartilage. The fibres at the back of the joint, sometimes styled the **posterior sterno-clavicular ligament,** are stronger than those in front or below, and consist of two sets: a superficial, passing upwards and outwards from the manubrium sterni, to the projecting posterior edge of the inner end of the clavicle, a few being prolonged onwards upon the posterior surface of the bone. A deeper set of fibres, especially thick and numerous below the clavicle, connect the interarticular cartilage with the clavicle and with the sternum, but do not extend from one bone to the other. The fibres in front, the **anterior sterno-clavicular ligament**, are well marked, but more lax and less tough than the posterior, and are overlaid by the tendinous sternal origin of the *sterno-mastoid*, the fibres of which run parallel to those of the ligament. They extend obliquely upwards and outwards from the margin of the sternal facet to the anterior surface of the clavicle some little distance from the articular margin. The fibres which cover in the joint **below** are short, woolly, and consist more of fibro-areolar tissue than true fibrous tissue; they extend from the upper border of the first costal cartilage to the lower border of the clavicle just external to the articular margin, and fill up the gap between it and the rhomboid ligament. The **superior portion** consists of short tough fibres passing from the sternum to the interarticular cartilage; and of others welding the fibro-cartilage to the upper edge of the clavicle, only a few of them passing from the clavicle direct to the sternum.

FIG. 219.—POSTERIOR VIEW OF THE STERNO-COSTO-CLAVICULAR JOINT.

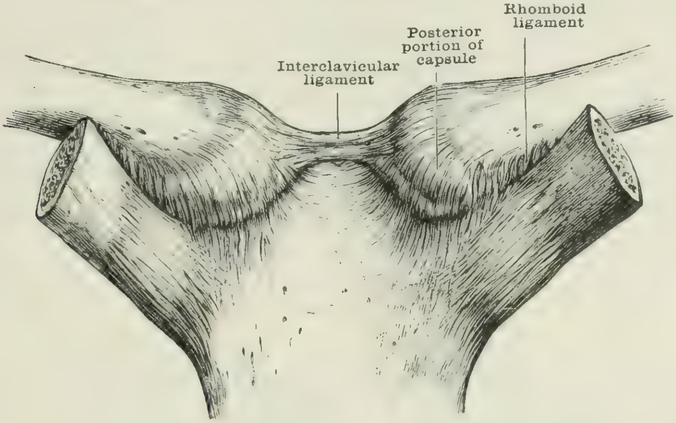
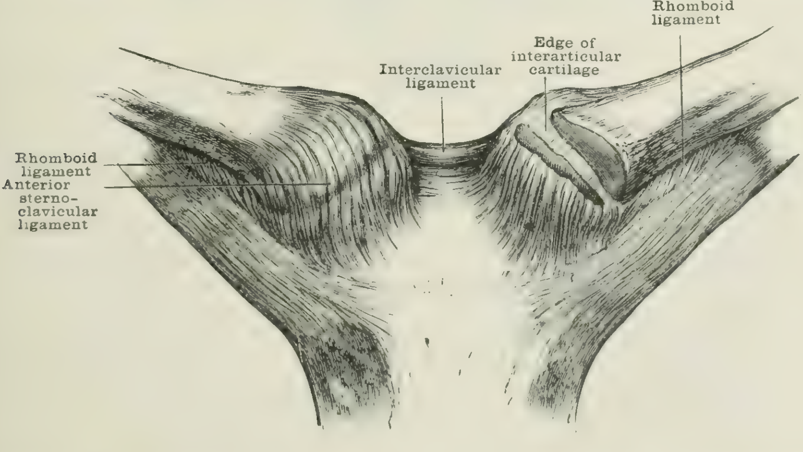

Rhomboid ligament
Posterior portion of capsule
Interclavicular ligament

FIG. 220.—ANTERIOR VIEW OF STERNO-COSTO-CLAVICULAR JOINT.

(The capsule is cut into on the left side to show the interarticular fibro-cartilage dividing the joint into two cavities.)

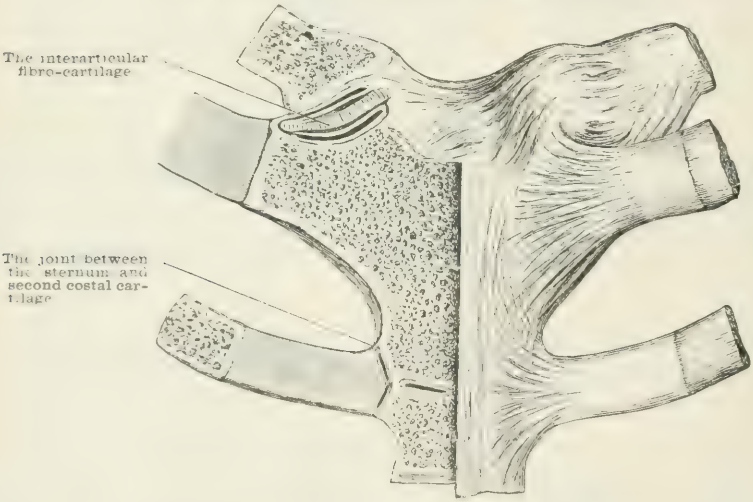

Rhomboid ligament
Edge of interarticular cartilage
Interclavicular ligament
Rhomboid ligament
Anterior sterno-clavicular ligament

The **interclavicular ligament** (figs. 219 and 220) is a strong, concave band, materially strengthening the superior portion of the capsule. It is nearly a quarter of an inch (6 mm.) deep, with the concavity upwards, its upper border tapering to a narrow, almost sharp edge. It is connected with the posterior superior angle of the sternal extremity of each clavicle, and with the fibres which weld the interarticular cartilage with the clavicle; and then passes across from clavicle to clavicle along the posterior aspect of the upper border of the manubrium sterni. The lowest fibres are attached to the sternum, and join the posterior fibres of the capsule of each joint. In the middle line between the ligament and the sternum there is an aperture for the passage of a small artery and vein.

The **rhomboid** or **costo-clavicular ligament** (figs. 219 and 220) is a strong dense band, composed of fine fibres massed together into a membranous structure. It extends from the anterior edge of the upper border of the first costal cartilage, upwards, backwards, and distinctly outwards to the rhomboid impression on the under surface of the inner extremity of the clavicle, to which it is attached just external to the lower part of the capsule. Frequently some of the outer fibres pass upwards and inwards behind the rest, and give the appearance of decussating. It is from half to three-quarters of an inch (1·5–2 cm.) broad.

The **interarticular fibro-cartilage** (figs. 220 and 221) is a flattened disc of nearly the same size and outline as the inner articular end of the clavicle, which it fairly accurately fits. It is attached, above to the upper border of the posterior edge of the clavicle; and below to the cartilage of the first rib at its union with the sternum, where it assists in forming the socket for the clavicle. At its circumference it is connected with the capsular ligament, and this connection is very strong behind, and still stronger above where it is blended with the interclavicular ligament. It is usually thinnest below, where it is connected with the costal cartilage. It varies in thickness in different parts, sometimes being thinner in the centre than at the circumference, sometimes the reverse, and is occasionally perforated in the centre. It divides the joint into two compartments.

FIG. 221.—SECTION THROUGH STERNO-CLAVICULAR JOINT.


The interarticular fibro-cartilage
The joint between the sternum and second costal cartilage

There are two **synovial membranes** (figs. 220 and 221): an outer one, which is reflected from the clavicle and capsule over the outer side of the fibro-cartilage, and is looser than the inner; the inner is reflected from the sternum over the inner side of the fibro-cartilage, costal cartilage, and capsule. Occasionally a communication takes place between them.

The **arterial supply** is derived from branches (1) from the internal mammary; (2) from the superior thoracic branch of the axillary; (3) twigs of a muscular branch often arising from the subclavian artery pass over the interclavicular notch; (4) twigs of the suprascapular artery.

The **nerve-supply** is derived from the nerve to the *subclavius* and sternal descending branch of the cervical plexus.

The **movements** permitted at this joint are various, though limited owing to the capsular ligament being moderately tense in every position of the clavicle.

Motion takes place in nearly every direction—viz. upwards, downwards, forwards, backwards, and in a circumductory manner. The upward and downward motions occur between the clavicle and the fibro-cartilage; during elevation of the arm, the upper edge of the clavicle with its attached fibro-cartilage is pressed into the sternal socket, and the lower edge glides away from the cartilage; during depression of the limb, the lower edge of the clavicle presses on to the cartilage, while the rest of the articular surface of the clavicle inclines outwards, bringing with it to a slight degree the upper edge of the fibro-cartilage. These movements occur on an antero-posterior axis drawn through the outer compartment of the joint. The forward and backward motions take place between the cartilage and sternum, the clavicle with the cartilage rolling backwards upon the sternum when the shoulder is brought forwards, and forwards when the shoulder is forced backwards; these movements occur round an axis drawn nearly vertically through the sternal socket.

The interarticular cartilage serves materially to bind the bones together, and to prevent the inward and upward displacements of the clavicle. It also forms an elastic buffer which tends to break shocks. The capsule, by being moderately tight, tends to limit movements in all directions, while the interclavicular ligament is a safeguard against upward displacement during depression of the arm. The rhomboid ligament prevents dislocation upwards during elevation of the arm, and resists displacements backwards.

(2) THE SCAPULO-CLAVICULAR UNION

The scapula is connected with the clavicle by a synovial joint with its ligaments; and also by a set of ligaments passing between the coracoid process and the clavicle. So that we have to consider—

(*a*) The **acromio-clavicular articulation.**

(*b*) The **coraco-clavicular ligaments.**

(*c*) The **proper scapular ligaments** are also best described in this section—viz. the **coraco-acromial** and **transverse.**

(*a*) The Acromio-clavicular Joint

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The acromio-clavicular joint is surrounded by a capsular ligament and frequently contains an interarticular fibro-cartilage.

The **capsular ligament** (figs. 223 and 226) completely surrounds the articular margins, and is composed of strong, coarse fibres arranged in parallel fasciculi, of fairly uniform thickness, which are attached to the borders as well as the surfaces of the bones. It is somewhat lax in all positions of the joint, so that the clavicle is not tightly braced to the acromion. The fibres extend three-quarters of an inch (2 cm.) along the clavicle posteriorly, but only a quarter of an inch (6 mm.) anteriorly. Superiorly, they are attached to an oblique line joining these two points, while inferiorly they reach to the ridge for the trapezoid ligament with which they blend. At the acromion they extend half way across the upper and lower surfaces, but at the anterior and posterior borders of that process they are attached close to the articular facet. The anterior fibres become blended with the insertion of the coraco-acromial ligament. The fibres are strengthened above by the aponeuroses of the *trapezius* and *deltoid* muscles; and all run from the acromion to the clavicle inwards and backwards.

The **interarticular fibro-cartilage** is occasionally present, but is usually imperfect, only occupying the upper part of the joint; it may completely divide the joint into two cavities, or be perforated in the centre. It is usually thicker at the edge than in the centre, and some of the fibres of the capsular ligament are blended with its edges.

The **synovial membrane** lining the joint is occasionally either partially or entirely divided into two by an interarticular fibro-cartilage.

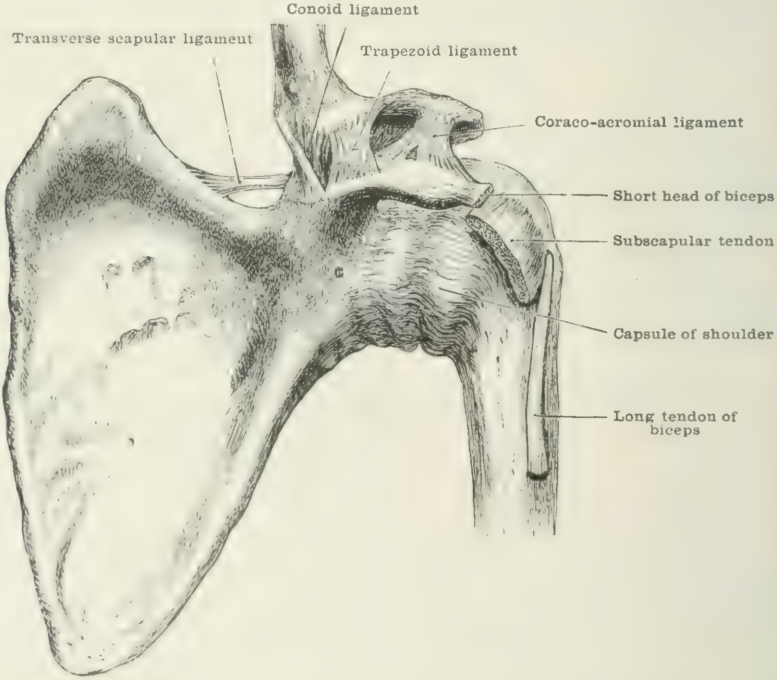
(b) The Coraco-clavicular Union

The **coraco-clavicular ligament** (figs. 222, 223 and 226) consists of two parts, the conoid and the trapezoid ligaments.

The **conoid ligament** is the internal and posterior portion, and passes upwards and outwards from the coracoid process to the clavicle. It is a very strong and coarsely fasciculated band of triangular shape, the apex being fixed to the inner and posterior edge of the root of the coracoid process just in front of the suprascapular notch, some fibres joining the transverse ligament. Its base is at the clavicle, where it widens out, to be attached to the posterior edge of the under surface, as well as to the conoid tubercle. It is easily separated from the trapezoid without being absolutely distinct. A small bursa often exists between it and the coracoid process; internally, some of the fibres of the *subclavius* muscle are often attached to it.

The **trapezoid ligament** is the anterior and outer portion. It is a strong, flat, quadrilateral plane of closely-woven fibres, the surfaces of which look upwards and inwards towards the clavicle, and downwards and outwards over the upper surface of the coracoid process. At the coracoid it is attached for about an inch (2·5 cm.) to a rough ridge which runs forwards from the angle, along the anterior border of the process. At the clavicle, it is attached to the oblique ridge which runs outwards and forwards from the conoid tubercle, reaching as far as, and blending with the inferior part of the acromio-clavicular ligament. Its anterior edge is free, and overlies the coraco-acromial ligament; the posterior edge is shorter than the anterior, and is in contact with the posterior and outer portion of the conoid ligament.

Fig. 222.—Anterior View of Shoulder, showing also Coraco-clavicular and Coraco-acromial Ligaments.



The **arterial supply** is derived from the suprascapular, acromial branches of the acromio-thoracic, and the anterior circumflex.

The **nerve-supply** is derived from the suprascapular and circumflex nerves.

Movements.—In the movements of the shoulder girdle, the scapula moves upon the outer end of the clavicle, and the clavicle, in turn, carried by the uniting ligaments, moves upon the sternum; so that the entire scapula moves in the arc of a circle whose centre is at the sterno-clavicular joint, and whose radius is the clavicle. The scapula, in moving upon the clavicle, also moves upon the thorax forwards and backwards, upwards and downwards, and also in a rotatory direction upon an axis drawn at right angles to the centre of the bone. Throughout these movements the lower angle and base of the scapula are kept in contact with the ribs by the *latissimus dorsi* which straps down the former, and the *rhomboids* and *serratus magnus* which brace down the latter. The glenoid cavity could not have preserved its obliquely forward direction had there been no acromio-clavicular joint, but would have shifted round a vertical axis, and thus the shoulder would have pointed inwards when the scapula was advanced, and outwards when it was drawn backwards. By means of the acromio-clavicular joint, the scapula can be forcibly advanced upon the thorax, the glenoid cavity all the time keeping its face duly forwards. Thus the muscles of the shoulder and forearm can be with advantage combined, as, for example, in giving a direct blow. The acromio-clavicular joint also permits the lower angle of the scapula to be retained in contact with the chest wall during the rising and falling of the shoulder, the scapula turning in a hinge-like manner round the horizontal axis of the joint.

There are no actions in which the scapula moves on a fixed clavicle, or the clavicle on a fixed scapula; the two bones, bound together by their connecting ligament, must move in unison.

(*c*) The Proper Scapular Ligaments

There are three proper ligaments of the scapula, which pass between different portions of the bone, viz.—

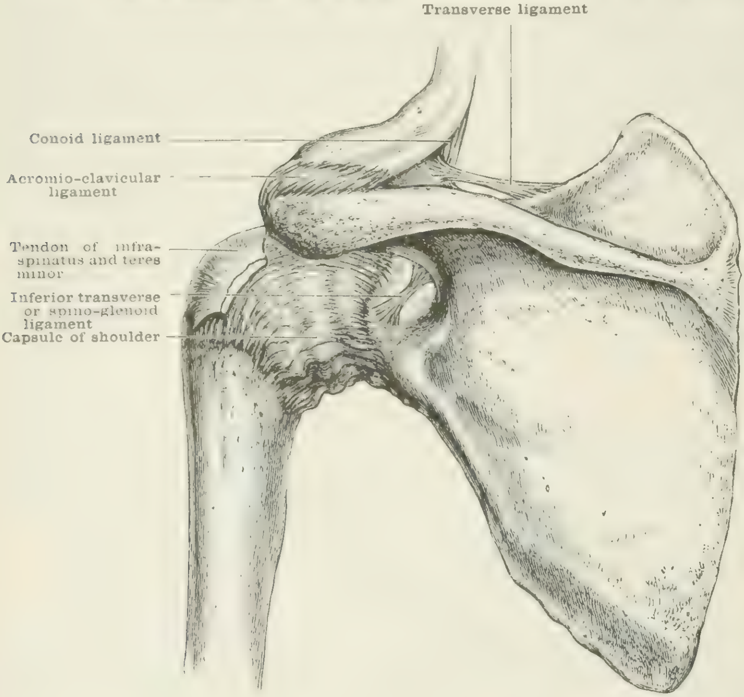
Coraco-acromial. Transverse.
Inferior transverse.

The **coraco-acromial ligament** (figs. 222 and 226) is a flat, triangular band with a broad base, attached to the outer border of the coracoid process, and a blunt apex which is fixed to the tip of the acromion. It is made up of two broad marginal bands, and a smaller and thinner intervening portion. The **anterior band,** which arises from the anterior portion of the coracoid process, is the stronger, and some of its marginal fibres can often be traced into the short head of the biceps, which can then make tense this edge of the ligament. The **posterior band,** coming from the posterior part of the coracoid process, is also strong. The intermediate part, of variable extent, is thin and membranous, containing but few ligamentous fibres; it is often incomplete near the coracoid process, leaving a small gap (fig. 222). The superior surface of the ligament looks upwards and a little forwards, and is covered by the *deltoid* muscle; the inferior looks downwards and a little backwards, and is separated from the capsule of the shoulder-joint by a bursa. At the coracoid process it overlies the coraco-humeral ligament. It is barely one-third of an inch (8 mm.) above the capsule of the shoulder, and in the undissected state there is scarcely a quarter of an inch (6 mm.) interval. The anterior band projects over the centre of the head of the humerus, and is continued into a tough fascia under the deltoid; the posterior band is continuous with the fascia over the supra-spinatus muscle. It binds the two processes firmly together, and so strengthens each; it holds the deltoid off the capsule of the shoulder, and protects the joint from slight injuries directed downwards and backwards against it.

The **transverse, coracoid,** or **suprascapular ligament** (figs. 222, 223 and 224) is a small triangular band of fibrous tissue, the surfaces of which look forwards and backwards; and its edges, which are thin and sharp, are turned upwards and downwards. It continues the superior border of the scapula, bridging over the suprascapular notch. It is broader internally, where it springs from the upper border of the scapula on its dorsal surface; and narrow externally, where it is attached to the base of the coracoid process; some of its fibres are inserted under the edge of the trapezoid ligament, and others pass upwards with the conoid to reach the clavicle. The *suprascapular artery* passes over it, and the *suprascapular nerve* beneath it. Internally, some fibres of the *omo-hyoid* muscle arise from it.

The **inferior transverse** or **spino-glenoid ligament** (fig. 223) reaches from the external border of the spine of the scapula to the margin of the glenoid cavity, and so forms a foramen under which the *suprascapular vessels* and *nerve* gain the infraspinous fossa. It is usually a weak membranous structure with but few ligamentous fibres.

Fig. 223.—Posterior View of the Shoulder-Joint, showing also the Acromio-clavicular Joint and the Special Ligaments of the Scapula.


Transverse ligament
Conoid ligament
Acromio-clavicular ligament
Tendon of infraspinatus and teres minor
Inferior transverse or spino-glenoid ligament
Capsule of shoulder

3. THE SHOULDER-JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Enarthrodia.*

The shoulder is one of the most perfect, and most movable of joints, the large upper end of the humerus playing upon the shallow glenoid cavity. Like the hip, it is a ball-and-socket joint. It is retained in position much less by ligaments than by muscles and the effects of atmospheric pressure; and, owing to the looseness of its capsule, as well as to all the other conditions of its construction and position, it is exceedingly liable to be displaced; on the other hand, it is sheltered from violence by the two projecting processes—the acromion and coracoid.

The ligaments of the shoulder-joint are:—

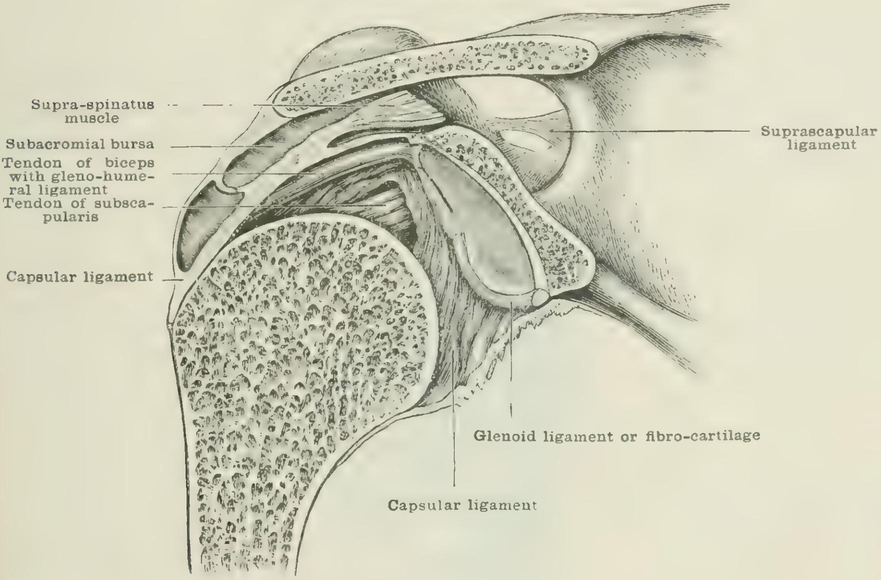
Capsular.
Gleno-humeral.
Coraco-humeral.
Glenoid.

The **capsular ligament** (figs. 222, 223 and 224) is a loose sac, insufficient in itself to maintain the bones in contact. It consists of fairly distinct but not coarse fibres, closely woven together, and directed, some straight, others obliquely, between the two bones, a few circular ones being interwoven amongst them. At the scapula, it is fixed on the dorsal aspect to the prominent rough surface of the glenoid process, reaching as far as the neck of the bone. Above, it is attached to the root of the coracoid process: in front, to the ventral surface of the glenoid process, at a variable distance from the articular margin, often reaching half an inch (12 mm.) upon the neck of the bone, and thus allowing the formation of a pouch; it may not, however, extend for more than a quarter of an inch (6 mm.) beyond the articular margin: below, it blends with the origin of the long head of the triceps. At the humerus, the upper half is fixed to the anatomical neck, sending a prolongation downwards between the two tuberosities which attenuates as it descends, and covers the transverse humeral ligament. The lower half of the capsule descends upon the humerus further from the articular margin, some of the deeper fibres being reflected upwards so as to be attached close to the articular edge, thus forming a kind of fibrous investment for the neck of the humerus. This ligament is more uniform in thickness than that of the hip.

Gleno-humeral bands of the capsule (figs. 224 and 225).—There are three accessory bands which strengthen the capsule, two of which are seen superficially, and consist of a few strengthening fibres, one on the **inner** aspect reaching from the glenoid cavity to the lower border of the lesser tuberosity along the lower border of the subscapularis tendon; and the **inferior** reaching from the under part of the glenoid cavity to the under part of the neck of the humerus. The third, the **superior** band, is known as the **gleno-humeral ligament,** and can only be seen after opening the capsule. It runs from the edge of the glenoid cavity at the root of the coracoid process, just internal to the origin of the long tendon of the biceps, and, passing inwards and downwards at an acute angle to the tendon, for which it forms a slight groove or sulcus, is fixed to the lesser tuberosity of the humerus. It is a thin, ribbon-like band, of which the upper surface is attached to the capsule, while the other is free and turned towards the joint. In the fœtus it is often, and in the adult occasionally, quite free from the capsule, and may be as thick as the long tendon of the biceps (fig. 225).

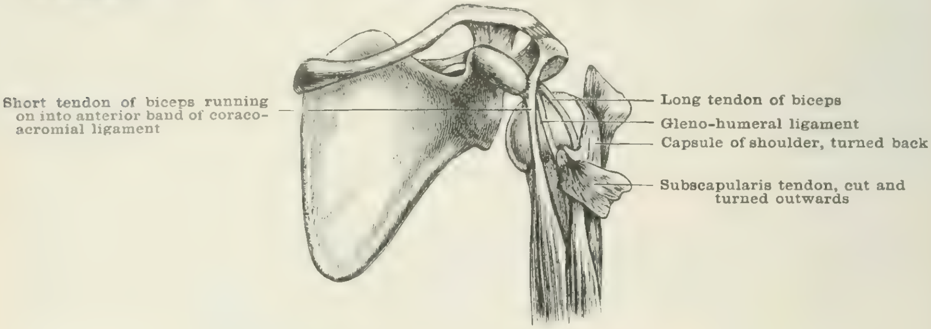
Fig. 224.—Vertical Section through the Shoulder-joint to show the Gleno-humeral Ligament.

(The joint is opened from behind.)



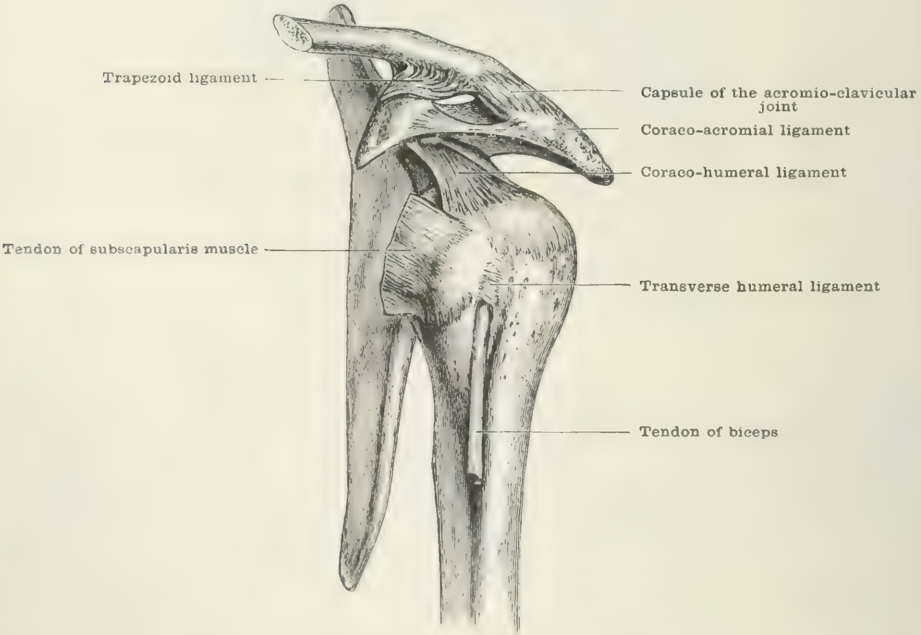
The tendons of the *supra-* and *infra-spinatus*, *teres minor*, and *subscapularis* muscles strengthen and support the capsule, especially near their points of insertion, and can be with difficulty dissected off from it. The long head of the *triceps* supports and strengthens the capsule below. The capsule also receives an upward slip from the *pectoralis major*. The *supra-spinatus* often sends a slip into the capsule from its upper edge (fig. 224).

Fig. 225.—Foetal Shoulder-joint, showing the Gleno-humeral Ligament, and also the Short Head of the Biceps, being continuous with the Coraco-acromial Ligament.


Short tendon of biceps running on into anterior band of coraco-acromial ligament
Long tendon of biceps
Gleno-humeral ligament
Capsule of shoulder, turned back
Subscapularis tendon, cut and turned outwards

The **coraco-humeral ligament** (fig. 226) is a strong broad band, which is attached above to the outer edge of the root and horizontal limb of the coracoid process nearly as far as the tip. From this origin it is directed backwards along the line of the biceps tendon to blend with the capsule, and is inserted into the greater tuberosity of the humerus. Seen from the back, it looks like an uninterrupted continuation of the capsule, while from the front it looks like a fan-shaped prolongation from it overlying the rest of the ligament. At its origin there is sometimes a bursa between it and the capsule.

Fig. 226.—Outer View of the Shoulder-joint, showing the Coraco-humeral and Transverse Humeral Ligaments.

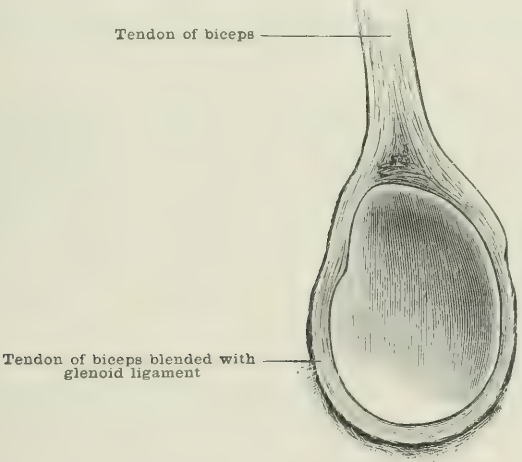

Trapezoid ligament
Capsule of the acromio-clavicular joint
Coraco-acromial ligament
Coraco-humeral ligament
Tendon of subscapularis muscle
Transverse humeral ligament
Tendon of biceps

The **glenoid ligament** (figs. 224 and 227) is a narrow rim of dense fibro-cartilage, which surrounds the edge of and deepens the glenoid socket. It is about a quarter of an inch (6 mm.) wide above and below, but less at the sides. Its outer edge is inseparably welded, near the bone, with the capsular ligament. Its structure is almost entirely fibrous, with but few cartilage cells intermixed. At the upper part of the fossa the **biceps tendon** is prolonged into the glenoid ligament, the tendon usually dividing and sending fibres right and left into the ligament, which may wind round nearly the whole circumference of the socket. It may, however send fibres into one side only, usually into the outer.

The **articular cartilage** covering the glenoid fossa is thicker at the circumference than in the centre, thus tending to deepen the cavity. It is usually thickest at the lower part of the fossa; over the head of the humerus the cartilage is thickest at and below the centre.

The **synovial membrane** lines the glenoid ligament, and is then reflected over the capsule as far as its attachment to the humerus, from which it ascends as far as the edge of the articular cartilage. The tendon of the *biceps* receives a long tubular sheath, which is continuous with the synovial membrane, both at its attached extremity and at the bicipital groove, but is free in the rest of its extent. The synovial cavity sometimes communicates with the bursa under the *subscapularis*, and less frequently with one under the infra-spinatus muscle. It also sends a pouch-like prolongation beneath the coracoid process when the fibrous capsule is attached wide of the margin of the glenoid fossa. A few fringes are seen near the edge of the glenoid cavity, and there is often one which runs down the inner edge of the biceps tendon, extending slightly below it and making a slight groove for the tendon to lie in.

FIG. 227.—BICEPS TENDON, BIFURCATING AND BLENDING ON EACH SIDE WITH THE GLENOID FIBRO-CARTILAGE.



The **transverse humeral ligament** (fig. 226) is so closely connected with the capsule of the shoulder that, although it is a proper ligament of the humerus, it may well be described here. It is a strong band of fibrous tissue, which extends between the two tuberosities, roofing in the bicipital canal. It is covered by a thin expansion of the capsule. It is limited to the portion of the bone above the line of the epiphysis. (C. Gordon Brodie, Journ. Anat. xxiv. 247.)

The following muscles are **in relation** with the capsular ligament: above, the *supra-spinatus;* externally, the *infra-spinatus* and *teres minor;* below, the long head of the *triceps;* internally, the tendon of the *subscapularis.* The *deltoid* covers the outer and upper surfaces of the joint, but is separated from the capsule by a bursa, and the tendons of the short rotator muscles. An upward slip from the *pectoralis* *major* joins the capsule below. Internally are the *long tendon* of the *biceps* and the gleno-humeral ligament.

The **arterial supply** is derived from the suprascapular, anterior and posterior circumflex, subscapular, dorsalis scapulæ, and a branch from the second portion of the axillary artery.

The **nerve-supply** is derived from the suprascapular, by branches in both fossæ; and from the circumflex and subscapular nerves.

The **movements** of the shoulder-joint consist of flexion, extension, adduction and abduction, rotation and circumduction.

Flexion is the swinging forwards, extension the swinging backwards, of the humerus; abduction is the raising of the arm from, and adduction depression of the arm to, the side. In flexion and extension the head of the humerus moves upon the centre of the glenoid fossa round an oblique line corresponding to the axis of the head and neck of the humerus, flexion being more free than extension, and in extreme flexion the scapula follows the head of the humerus, so as to keep the articular surfaces in apposition. In extension the scapula moves much less, if at all.

In abduction and adduction the scapula is fixed, and the humerus rolls up and down upon the glenoid fossa; during abduction the head descends until it projects beyond the lower edge of the glenoid cavity, and the great tuberosity impinges against the arch of the acromion; during adduction, the head of the humerus ascends in its socket, the arm at length reaches the side, and the capsule is completely relaxed.

In circumduction, the humerus, by passing quickly through these movements, describes a cone, whose apex is at the shoulder-joint, and the base at the distal extremity of the bone or limb.

Rotation takes place round a vertical axis drawn through the extremities of the humerus from the centre of the head to the inner condyle; in rotation forwards (that is, inwards) the head of the bone rolls back in the socket as the great tuberosity and shaft are turned forwards; in rotation backwards (that is, outwards) the head of the bone glides forwards, and the tuberosity and shaft of the humerus are turned backwards, i.e. outwards.

Great freedom of movement is permitted at the shoulder, and this is increased by the mobility of the scapula. Restraint is scarcely exercised at all upon the movements of the shoulder by the ligaments, but chiefly by the muscles of the joint.

In abduction, the lower part of the capsule is somewhat, and in extreme abduction considerably, tightened; and in rotation inwards and outwards, the upper part of the capsule is made tense, as is also, in the latter movement, the coraco-humeral ligament.

The movements of abduction and extension have a most decided and definite resistance offered to them other than by muscles and ligaments, for the great tuberosity of the humerus, by striking against the acromion process and coraco-acromial ligament, stops short any further advance of the bone in these directions, and thus abduction ceases altogether as soon as the arm is raised to a right angle with the trunk, and extension shortly after the humerus passes the line of the trunk.

Further elevation of the arm beyond the right angle is effected by the rotation of the scapula round its own axis by the action of the trapezius and serratus magnus muscles upon the sterno-clavicular and acromio-clavicular joints.

The acromion and coracoid processes, together with the coraco-acromial ligament, form an arch, which is separated by a bursa and the tendon of the *supraspinatus* from the capsule of the shoulder. Beneath this arch the movements of the joint take place, and against it the head and tuberosities are pressed when the weight of the trunk is supported by the arms; the greater tuberosity and the upper part of the shaft impinge upon it when abduction and extension are carried to their fullest extent.

No description of the shoulder-joint would be complete without a short notice of the peculiar relation which the biceps tendon bears to the joint. It passes over the head of the humerus a little to the inner side of its summit, and lies free within the capsule, surrounded only by a tubular process of synovial membrane. It is flat, with the surfaces looking upwards and downwards, until it reaches the bicipital groove, when it assumes a rounded form. It strengthens the articulation along the same course as the coraco-humeral ligament, and tends to prevent the head of the humerus from being pulled upwards too forcibly against the under surface of the acromion. It also serves the purpose of a ligament by steadying the head of the humerus in various movements of the arm and forearm, and to this end is let into a groove at the upper end of the bone, from which it cannot escape on account of the abutting tuberosities and the strong transverse humeral ligament which binds it down. Further, it acts like the four shoulder muscles, which pass over the capsule to keep the head of the humerus against the glenoid socket; and, moreover, it resists the tendency of the *pectoralis major* and *latissimus dorsi* muscles, in certain actions when the arm is away from the side of the body, to pull the head of the humerus below the lower edge of the cavity.

4. THE ELBOW-JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

The elbow is a complete hinge, and, unlike the knee, depends for its security and strength upon the configuration of its bones rather than on the number, strength, or arrangement of its ligaments. The bones composing it are the lower end of the humerus above, and the upper ends of the radius and ulna below: the articular surface of the humerus being received partly within the great sigmoid cavity of the ulna, and partly upon the cup-shaped surface of the radius. The ligaments form one large and capacious capsule, which, by blending with the orbicular ligament, and then passing on to be attached to the neck of the radius, embraces the elbow and the superior radio-ulnar joints, uniting them into one. Laterally, it is considerably strengthened by superadded fibres arising from the condyles of the humerus and inseparably connected with the capsule. For convenience of description it will be spoken of as consisting of four portions:—

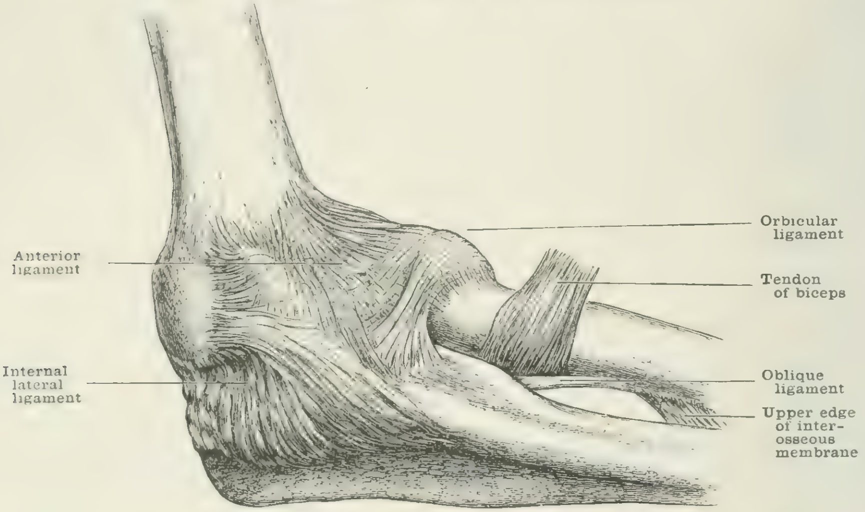
Anterior. Internal.
Posterior. External.

The **anterior portion** (fig. 228) is attached to the front of the humerus above the articular surface and coronoid fossa, in an inverted V-shaped manner, to two very faintly marked ridges which start from the front of the internal and external condyles, and meet at a variable distance above the coronoid fossa. Below, it is fixed, just beyond the articular margin, to the front of the coronoid process; it is intimately blended with the front of the orbicular ligament, a few fibres passing on to the neck of the radius. It varies in strength and thickness, being sometimes so thin as barely to cover the synovial membrane; at others, thick and strong, and formed of coarse decussating fibres, the majority of which descend from the inner side outwards to the radius.

The **posterior portion** (fig. 229), thin and membranous, is attached superiorly to the humerus, in much the same inverted V-shaped way as the anterior; ascending from the internal condyle, along the inner side of the olecranon fossa nearly to the top; then, crossing the bottom of the fossa, it descends on the outer side, skirting the outer margin of the trochlear surface, and turns outwards along the posterior edge of the capitellum. Inferiorly, it is attached to a slight groove along the superior and external surfaces of the olecranon, and the rough surface of the ulna just beyond the lesser sigmoid notch, and with the orbicular ligament, a few fibres passing on to the neck of the radius. It is composed of decussating fibres, most of which pass vertically or obliquely downwards, a few taking a transverse course at the summit of the olecranon fossa where the ligament is usually thinnest.

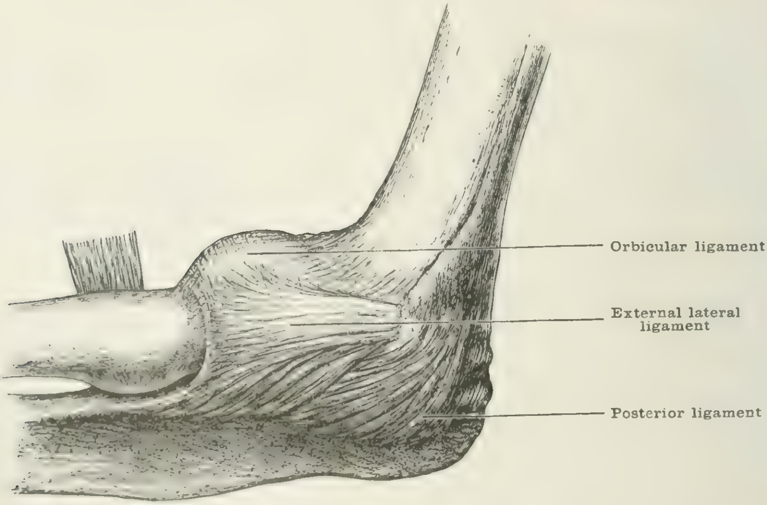
The **internal portion** (fig. 228) is thicker, stronger, and denser than either the anterior or posterior portions. It is triangular in form, its apex being attached to the anterior and under aspect of the internal condyle, and to the condyloid edge of the groove between the trochlea and the condyle. The fibres radiate downwards from this attachment, the anterior passing forwards to be fixed to the rough overhanging inner edge of the coronoid process; the middle descend less obliquely to a ridge running between the coronoid and olecranon processes, while the posterior pass obliquely backwards to the inner edge of the olecranon just beyond the articular margin. The anterior fibres are the thickest, strongest, and most pronounced.

FIG. 228.—INTERNAL VIEW OF THE ELBOW-JOINT.


Orbicular ligament
Anterior ligament
Tendon of biceps
Internal lateral ligament
Oblique ligament
Upper edge of interosseous membrane

The **external portion** (fig. 229) is attached above to the lower part of the external condyle, and from this the fibres radiate to their attachment into the outer side of the orbicular ligament, a few fibres being prolonged to reach the neck of the radius. The anterior fibres reach further forwards than the posterior do behind. It is strong and well-marked, but less so than the internal portion.

FIG. 229.—EXTERNAL VIEW OF THE ELBOW-JOINT.


Orbicular ligament
External lateral ligament
Posterior ligament

The **synovial membrane** lines the whole of the capsule, and extends into the superior radio-ulnar joint, lining the orbicular ligament. Outside the synovial membrane, but inside the capsule, are often seen some pads of fatty tissue; one is situated on the inner side at the base of the olecranon, another is seen on the outside projecting into the cavity between the radius and ulna; this latter, with a fold of synovial membrane opposite the front of the outer lip of the trochlea, suggests the division of the joint into two parts—one internally for the ulna, and another externally for the radius. There are also pads of fatty tissue at the bottom of the olecranon and coronoid fossæ, and at the tip of the olecranon process.

The **arterial supply** is derived from each of the vessels forming the free anastomosis around the elbow, and there is also a special branch to the front and outer side of the joint, from the brachial artery, and the arterial branch to the *brachialis anticus* also feeds the front of the joint.

The **nerve-supply** comes from the musculo-cutaneous chiefly; the ulnar, median, and musculo-spiral also give filaments to the joint.

The **movements** permitted at the elbow are those of a true hinge joint, viz. flexion and extension. These movements are oblique, so that the forearm is inclined inwards in flexion, and outwards in extension; they are limited by the contact respectively of the coronoid and olecranon processes of the ulna with their corresponding fossæ on the humerus, and their extent is determined by the relative proportion between the length of the processes and depth of the fossæ which receive them, rather than by the tension of the ligaments, or the bulk of the soft parts over them. The anterior and posterior portions of the capsule, together with the corresponding portions of the lateral ligament, are not put on the stretch during flexion and extension; but, although they may assist in checking the velocity, and thus prevent undue force of impact, they do not control or determine the extent of these movements. The limit of extension is reached when the ulna is nearly in a straight line with the humerus; and the limit of flexion when the ulna describes an angle of from 30° to 40° with the humerus.

The obliquity of these movements is due to the outward inclination of the upper and back part of the trochlear surface, and the greater prominence of the inner lip of the trochlea below; thus the plane of motion is directed from behind inwards and forwards, and carries the hand towards the middle third of the clavicle. The obliquity of the joint, the inward twist of the shaft of the humerus, and the backward direction of its head, all tend to bring the hand towards the mid line, under the immediate observation of the eye, whether for defence, employment, or nourishment. This is in striking contrast to the lower limb, where the direction of the foot diverges from the median axis of the trunk, thus preventing awkwardness in locomotion. In flexion and extension, the cup-like depression of the radial head glides upon the capitellum, and the inner margin of the radial head travels in the groove between the capitellum and the trochlea. This allows the radius to rotate upon the humerus while following the ulna in all its movements. In full extension and supination, the head of the radius is barely in contact with the inferior surface of the capitellum, and projects so much backwards that its posterior margin can be felt as a prominence at the back of the elbow. In full flexion the anterior edge of the radial head is received into, and checked against, the depression above the capitellum; while in mid-flexion the cup-like depression is fairly received upon the capitellum, and in this position, the radius being more completely steadied by the humerus than in any other, pronation and supination take place most perfectly.

5. THE UNION OF THE RADIUS WITH THE ULNA

The radius is firmly united to the ulna by two joints, and an intermediate fibrous union, viz. :—

(*a*) The **superior radio-ulnar,**—whereat the head of the radius *rotates* within the lesser sigmoid cavity and orbicular ligament.

(*b*) The **union of the shafts,**—the **mid radio-ulnar union.**

(*c*) The **inferior radio-ulnar,**—whereat the lower end of the radius *rolls round* the head of the ulna.

(a) THE SUPERIOR RADIO-ULNAR JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Trochoides.*

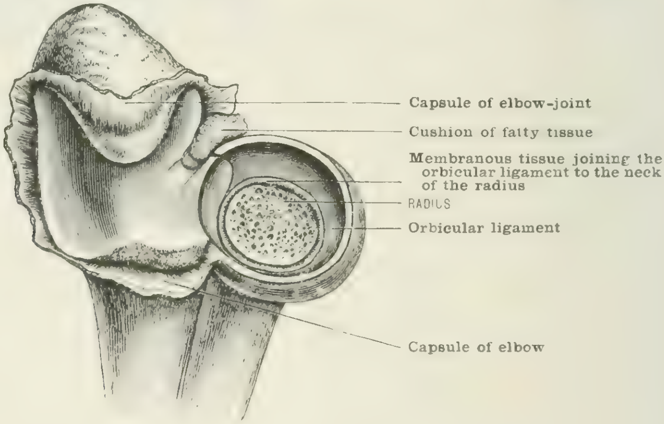
The bones which enter into this joint are, the ulna by its lesser sigmoid cavity, and the radius by the smooth vertical border or rim on its head. There is but one ligament special to the joint, viz.:—

Orbicular.

The **orbicular ligament** consists of bands of strong fibres, somewhat thicker than the capsule of the elbow-joint, which encircle the head of the radius, retaining it against the side of the ulna. The bulk of these fibres forms about three-fourths of a circle, and they are attached to the anterior and posterior margins of the lesser sigmoid cavity; some few are continued round below the lesser sigmoid cavity, and form a complete ligamentous circle. The ligament is inseparably connected along its upper edge and external (i.e. its non-articular) surface with the anterior, posterior, and external portions of the capsule of the elbow, a few of the fibres of these portions, especially of the external, descending to be attached to the neck of the radius. The lower part of the articulation is covered in by a thin independent membranous layer, which passes from the lower edge of the orbicular ligament to the neck of the radius, strengthened on the outer side by those fibres passing down from the capsule. They are loose enough to allow the bone to rotate upon its own axis (fig. 230).

FIG. 230.—ORBICULAR LIGAMENT.

(The head of the radius removed to show the membranous connection of this ligament with the radius.)



The **synovial membrane** is the same as that of the elbow, and, after lining the orbicular ligament, passes on to the neck of the radius, and thence up to the articular cartilage.

The **arterial** and **nerve-supply** are the same as those to the outer part of the elbow-joint.

(b) THE MID RADIO-ULNAR UNION

There are two interosseous ligaments which pass between the shafts of the bones and unite them firmly together, viz.:—

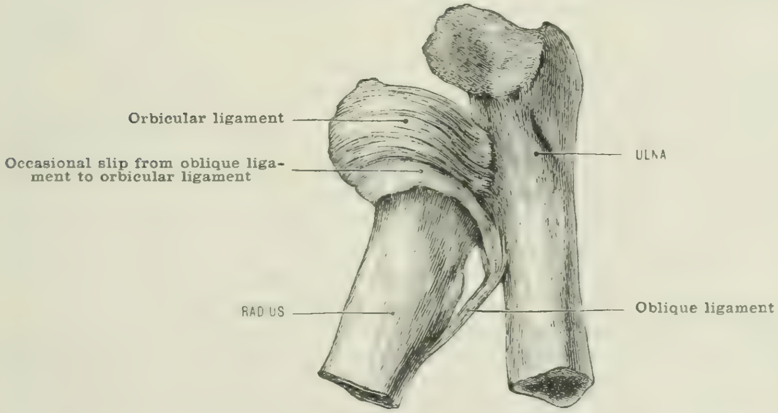
Oblique ligament. Interosseous membrane.

The **oblique ligament** (figs. 228 and 230 A) is a fairly strong, narrow band, which passes from the lower end of the rough outer border of the coronoid process, downwards and outwards to be attached to the posterior edge of the lower end of the bicipital tuberosity of the radius and the vertical ridge running from it to the inner border of the bone. Some of its fibres blend with the fibres of insertion of the biceps tendon; behind, it is in close contact with the *supinator brevis;* below, a thin membrane passes off from it to the upper edge of the interosseous membrane; the posterior interosseous vessels pass in the space between it and the interosseous membrane; occasionally a slip is continued into the orbicular ligament of the superior radio-ulnar articulation (see fig. 230 A).

The **interosseous membrane** (fig. 228) is attached to the ulna at the lowest part of the ridge in front of the depression for the supinator brevis, and along the whole length of the interosseous border as far as the inferior radio-ulnar articulation, approaching the front of the bone in the lower part of its attachment. To the radius it is attached along the interosseous border, from an inch (2·5 cm.) below the bicipital tuberosity to the sigmoid notch for the lower end of the ulna. It is strongest and broadest in the centre, where the fibres are dense and closely packed; it is also well marked beneath the *pronator quadratus*, and thickens considerably at the lower end, forming a strong band of union between the two bones. Its fibres pass chiefly downwards and inwards, from the radius to the ulna, though some take the opposite direction; at the lower end some are transverse. On the posterior surface are one or two bands, which pass downwards and outwards from the ulna to the radius, and frequently there is a strong bundle as large as the oblique ligament; this, which should be called the **inferior oblique ligament** (fig. 234), stretches from the ulna, an inch and a half above its lower extremity, downwards and outwards to the ridge above and behind the sigmoid notch of the radius.

FIG. 230 A.—UPPER PORTIONS OF LEFT ULNA AND RADIUS WITH OBLIQUE AND ORBICULAR LIGAMENTS: TO SHOW AN OCCASIONAL SLIP FROM THE OBLIQUE LIGAMENT TO THE LOWER PART OF THE ORBICULAR LIGAMENT. This condition is present in the spider monkey (*Ateles*), which has no external thumb but only rudimentary bones of one.

(From a dissection by Mr. W. Pearson, Royal College of Surgeons, England.)



At its attachment to the bones, the interosseous membrane blends with the periosteum. Its upper border is connected with the **oblique ligament** by a thin membrane, which is pierced by the posterior interosseous vessels; and the lower border, which stretches across between the two bones just above the inferior radio-ulnar articulation, assists in completing the capsule of that joint. Its anterior surface is in relation with the *flexor profundus digitorum* and *flexor longus pollicis* in the upper three-quarters, the lower fourth being in relation with the *pronator quadratus.* The anterior interosseous vessels and nerve descend along the middle of the membrane, the artery being bound down to it. About an inch from the lower end, it is pierced by the anterior interosseous artery. The posterior surface is in relation with the *supinator brevis, extensor ossis metacarpi, extensor primi, extensor secundi internodii pollicis,* and the *extensor indicis;* at its lower part, also with the posterior branch of the anterior interosseous artery.

(c) THE INFERIOR RADIO-ULNAR JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Trochoides.*

This is, in one respect, the reverse of the superior; for the radius, instead of presenting a circular head to rotate upon the facet on the ulna, presents a concave facet which rolls round the ulna. The articulation may be said to consist of two parts at right angles to each other: one between the radius and ulna, and the other between the ulna and triangular fibro-cartilage.

The ligaments are:—

Anterior radio-ulnar. Posterior radio-ulnar.
Triangular fibro-cartilage.

The **triangular fibro-cartilage** (figs. 234 and 235) assists the radius in forming an arch under which is received the first row of carpal bones. Its base is attached to the margin of the radius, separating the sigmoid cavity from the articular surface for the carpus, while its apex is fixed to the fossa at the base of the styloid process of the ulna. It gradually and uniformly diminishes in width from base to apex, becoming rounded where it is fixed to the ulna; it is joined by fibres of the internal lateral ligament of the wrist. It is about three-eighths of an inch (1 cm.) wide, and the same from base to apex; thicker at the circumference than in the centre; smooth and concave above to adapt itself to the ulna, and smooth and slightly concave below to fit over the cuneiform bone. Its anterior and posterior borders are united to the anterior and posterior radio-ulnar and radio-carpal ligaments. It is the most important structure in the inferior radio-carpal articulation, as it is a very firm bond of union between the lower ends of the bones, and serves to limit their movements upon one another more than any other structure in either the upper or lower radio-ulnar joints. Its structure is fibrous at the circumference, while in the centre there is a preponderance of cells. It differs from all other fibro-cartilages in entering into two distinct articulations; and separates entirely the synovial membrane of the radio-ulnar joint from that of the wrist.

The **anterior radio-ulnar ligament** (fig. 231) is attached by one end to the anterior edge of the sigmoid cavity of the radius, and by the other to the rough bone above the articular surface of the ulna as far inwards as the notch, as well as into the anterior margin of the triangular cartilage from base to apex.

The **posterior radio-ulnar ligament** (fig. 232) is similarly attached to the posterior margin of the sigmoid cavity at one end, and at the other to the rough bone above the articular surface of the extremity of the ulna as far inwards as the groove for the *extensor carpi ulnaris*, with the sheath of which it is connected, as well as into the whole length of the posterior margin of the triangular fibro-cartilage. Both the radio-ulnar ligaments consist of thin, almost scattered, fibres, but they serve to form a capsule for the support and protection of the synovial membrane.

The lower end of the **interosseous membrane** extends between the ulna and radius immediately above their points of contact. Transverse fibres between the two bones form a sort of arch above the concave articular facet of the radius, and, joining the anterior and posterior radio-ulnar ligaments, complete the capsule of the inferior radio-ulnar joint.

The **synovial membrane**, sometimes called **the membrana sacciformis,** is large and loose in proportion to the size of the joint. It is not only interposed between the radial and ulnar articular surfaces, but lines the terminal articular surface of the ulna and the upper surface of the triangular fibro-cartilage.

The **arterial supply** is derived from the anterior interosseous artery, and branches of the anterior carpal arch.

The **nerve-supply** comes from the anterior interosseous of the median, and the posterior interosseous branch of the musculo-spiral.

The movements of the radius.—The upper end of the radius rotates upon an axis drawn through its own head and neck within the collar formed by the lesser sigmoid cavity and the orbicular ligament, while the lower end, retained in position by the triangular ligament, rolls round the head of the ulna. This rotation is called *pronation*, when the radius from a position nearly parallel to the ulna turns inwards so as to lie obliquely across it; and *supination*, when the radius turns back again from within outwards, so as to uncross and lie nearly parallel with the ulna. In these movements, the radius carries with it the hand, which rotates on an axis passing a little to the inner side of the middle line; thus, the hand when pronated, lies with its dorsum upwards, as in playing the piano, while when supinated, the palm lies upwards—the attitude of a beggar asking alms. Ward thus expresses the relations of the two extremities of the radius in pronation and supination: 'The head of the radius is so disposed in relation to the sigmoid cavity at the lower end that the axis of the former if prolonged falls upon the centre of the circle of which the latter is a segment;' the axis thus passes through the lower end of the ulna at a point at which the triangular fibro-cartilage is attached, and if prolonged further, passes through the ring finger. Thus the radius describes, in rotating, a blunt-pointed cone whose apex is the centre of the radial head, and whose base is at the wrist; partial rotation of the bone being unaccompanied by any hinge-like or antero-posterior motion of its head, and pronation and supination occurring without disturbance to the parallelism of the bones at the superior radio-ulnar joint. Associated with this rotation in the ordinary way, there is some rotation of the humero-ulnar shaft, which causes lateral shifting of the hand from side to side; thus, with pronation there is some abduction, and with supination some adduction combined, so that the hand can keep on the same superficies in both pronation and supination. The power of supination in man is much greater than pronation, owing to the immense power and leverage obtained by the curve of the radius, and by the attachment of the biceps tendon to the back of the tubercle. For this reason all our screw-driving and boring tools are made to be used by supination movements.

In the undissected state, the amount of rotation it is possible to obtain is about 135°, so that neither the palm nor the fore part of the lower end of the radius can be turned completely in opposite directions; yet in the living subject this amount can be greatly increased by rotation of the humero-ulnar shaft at the shoulder-joint.

Pronation is checked in the living subject by (a) the posterior inferior radio-ulnar ligament, which is strengthened by the connection of the sheath of the extensor tendons with it; (b) the lowermost fibres of the interosseous membrane; (c) the back part of the internal and adjacent fibres of the posterior ligament of the wrist, and (d) the meeting of the soft parts on the front of the forearm.

Supination is checked mainly (a) by the internal lateral ligament of the wrist, but partly also by (b) the oblique radio-ulnar ligament; (c) the anterior inferior radio-ulnar ligament, and (d) the lowest fibres of the interosseous membrane.

The interosseous membrane serves, from the direction of its fibres downwards and inwards from the radius to the ulna, to transmit the weight of the body from the ulna to the radius in the extended position of the elbow, as in pushing forwards with the arms extended, or in supporting one's own weight on the hands, the ulna being in close contact with the humerus, but scarcely at all with the carpus; while the radius is scarcely in contact with the humerus, but in close contact with the carpus. Hence the weight transmitted by the ulna is communicated to the radius by the tightening of the interosseous membrane. Conversely, it falls upon the hand with the arm extended, the interosseous membrane acting as a sling to break the violence of the shock, and preventing the whole force of the impact from expending itself directly upon the capitellum.

6. THE RADIO-CARPAL ARTICULATION

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

The wrist-joint is formed by the union of the radius and triangular fibro-cartilage above, articulating with the scaphoid, semilunar, and cuneiform bones below; the ulna being excluded by the intervention of the triangular fibro-cartilage. The radius and triangular cartilage together present a smooth surface, slightly concave both from before backwards, and from side to side; whilst the three bones of the carpus present a smooth, convex surface, made uniformly even by the interosseous ligaments which bind them together.

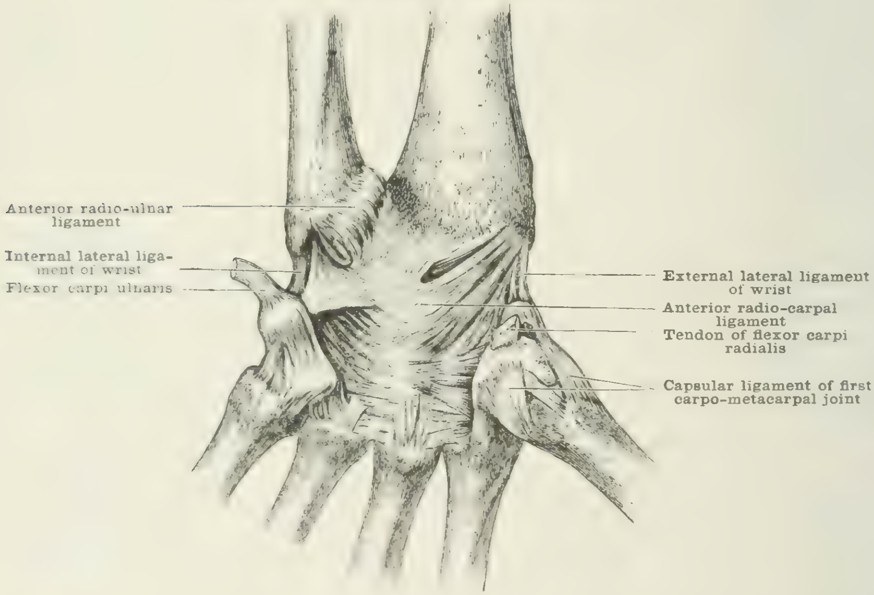
The capsule of the wrist-joint has been usually described as four separate ligaments, and it will be convenient for the sake of a complete description to follow this method; but it must be understood that these four portions are continuous around the joint, extending from styloid process to styloid process on both its aspects.

The four portions are:—

Anterior radio-carpal.	Internal lateral.
Posterior radio-carpal.	External lateral.

The **anterior radio-carpal** (fig. 231) is a thick strong ligament, attached superiorly to the radius immediately above the margin of the terminal articular facet, to the curved ridge at the root of the styloid process of the radius, and to the anterior margin of the triangular cartilage, blending with some fibres of the capsule of the inferior radio-ulnar joint. It passes downwards and inwards to be attached to both rows of carpal bones, especially the second, and to the anterior intercarpal ligament. The strongest and most oblique fibres arise from the root of the styloid process of the radius, and pass obliquely over the scaphoid, with which only a few fibres are connected, to be inserted into the semilunar, magnum, and cuneiform bones. Another set, less oblique, passes from the margin of the facet for the semilunar to be attached to the adjacent parts of the magnum, unciform, and cuneiform bones. Between the two sets of fibres, small vessels pass into the joint.

Fig. 231.—Anterior View of Wrist.

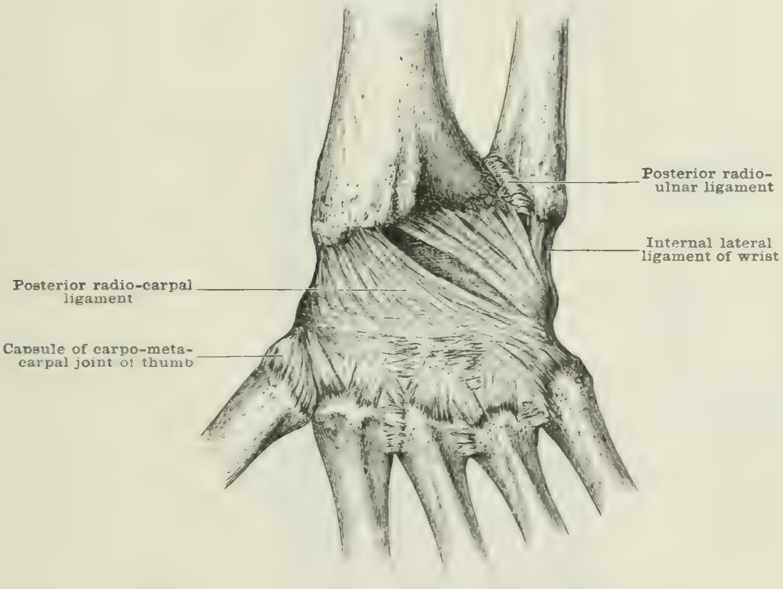

Anterior radio-ulnar ligament
Internal lateral ligament of wrist
Flexor carpi ulnaris
External lateral ligament of wrist
Anterior radio-carpal ligament
Tendon of flexor carpi radialis
Capsular ligament of first carpo-metacarpal joint

The **posterior radio-carpal ligament** (fig. 232) is attached above the dorsal edge of the lower end of the radius, the back of the styloid process, and the posterior margin of the fibro-cartilage. It passes downwards and inwards to be connected with the first row of the carpal bones, chiefly with the semilunar and cuneiform, and the posterior intercarpal ligament. This ligament is thin and membranous, and is strengthened by (i) strong fibres passing from the back of the fibro-cartilage, where they are blended with the posterior inferior radio-ulnar ligament, and, from the edge of the radius just behind the lesser sigmoid fossa, to the cuneiform bone; (ii) from the ridge and groove for the extensor secundi internodii pollicis to the back of the semilunar and cuneiform bones; and (iii) from the groove for the radial extensors to the back of the scaphoid and semilunar. It is in relation with, and strengthened by, the extensor tendons which pass over it.

The **internal lateral ligament** (fig. 232) is fan-shaped, with its apex above, at the styloid process of the ulna, to which it is attached on all sides, blending with the apex of the fibro-cartilage. Some of the fibres pass forwards and outwards to the base of the pisiform bone and to the inner part of the upper border of the anterior annular ligament, where it is attached to the pisiform bone; they form a thick, rounded fasciculus on the front of the wrist. Other fibres descend vertically to the inner side of the cuneiform bone, and others again outwards to the dorsal surface of the cuneiform. The tendon of the *extensor carpi ulnaris* is posterior to, and passes over, part of the fibres of the ligament.

The **external lateral ligament** (fig. 231) consists of fibres which radiate from the fore part and tip of the styloid process of the radius. Some pass downwards and inwards, in front, to the scaphoid and adjacent edge of the magnum; some downwards, a little forwards and inwards, to the tubercle of the scaphoid and ridge of the trapezium; and others downwards and outwards to the rough dorsal surface of the scaphoid. The fibres of this ligament are not so long and strong, nor do they radiate so much as those of the internal lateral ligament. It is in relation with the *radial artery*, and the *extensor ossis metacarpi* and *primi internodii pollicis*, the artery separating the tendons from the ligament.

Fig. 232.—Posterior View of Wrist.


Posterior radio-ulnar ligament
Internal lateral ligament of wrist
Posterior radio-carpal ligament
Capsule of carpo-meta-carpal joint of thumb

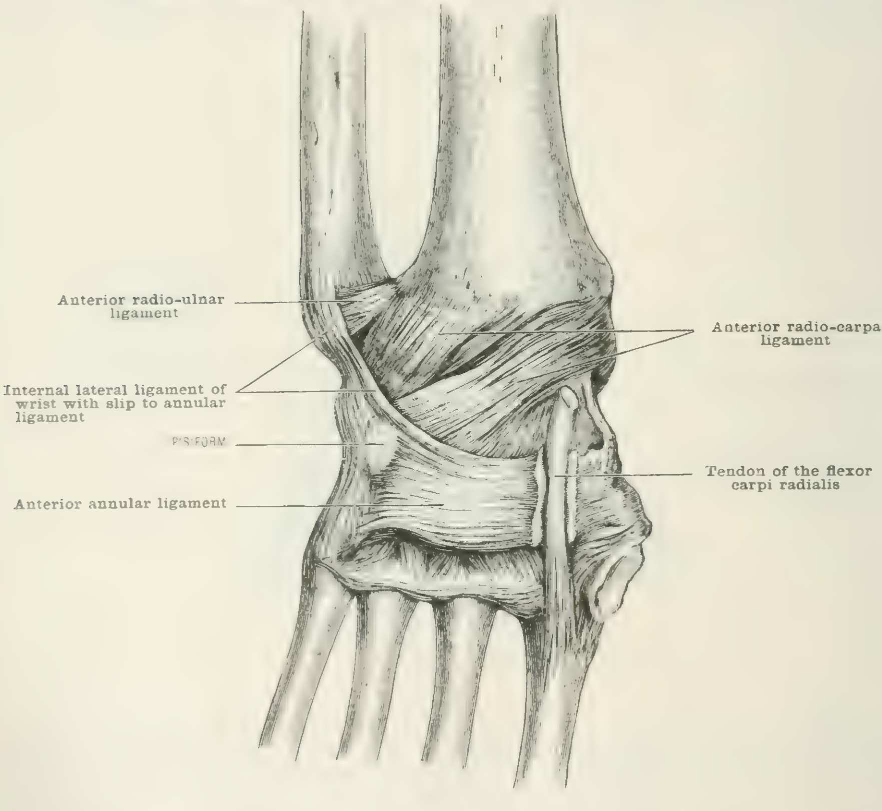
The **synovial membrane** is extensive, but does not usually communicate with the synovial membrane of the inferior radio-ulnar joint, being shut out by the triangular cartilage. It is also excluded, in almost every instance, from that of the carpal joints by the interosseous ligaments between the first row of carpal bones. The styloid process of the radius is cartilage-covered internally, and forms part of the articular cavity, while that of the ulna does not.

The **arterial supply** is derived from the anterior and posterior carpal arches, the posterior division of the anterior interosseous, from twigs direct from the radial and ulnar arteries, and from recurrent branches from the first dorsal interosseous.

The **nerve-supply** is derived from the ulnar and median in front, and the posterior interosseous behind.

Movements.—The wrist is a condyloid joint, the carpus forming the condyle. It allows of movements upon a transverse axis, i.e. flexion and extension; and around an antero-posterior axis, i.e. abduction and adduction; together with a combination of these in quick succession—circumduction. Lacking only rotation on a vertical axis, it thus possesses most of the movements of a ball-and-socket joint, without the weakness and liability to dislocation which are peculiar to these joints. This deficiency of rotation is compensated for by the movements of the radius at the radio-ulnar joints, viz. supination and pronation. Its strength depends chiefly upon the number of tendons which pass over it, and the close connection which exists between the fibrous tissue of their sheaths and the capsule of the wrist; also upon the proximity of the medio-carpal and carpo-metacarpal joints, which permits shocks and jars to be shared and distributed between them; another source of strength is the absence of any long bone on the distal side of the joint. In flexion and extension the carpus rolls forwards and backwards beneath the arch formed by the radius and fibro-cartilage: flexion being limited by the posterior ligament and posterior portions of the lateral; extension by the anterior, and anterior portions of the lateral ligaments. In adduction and abduction, the carpal bones glide from without inwards and from within outwards. Abduction is more limited than adduction, and is checked by the internal lateral ligament and by contact of the styloid process of the radius with the trapezium; adduction is checked by the external lateral ligament alone. One reason for adduction being more free than abduction is that the ulna does not reach so low down as the radius, and the yielding fibro-cartilage allows of greater movement upwards of the inner end of the carpus. In circumduction the hand moves so as to describe a cone, the apex of which is at the wrist. These movements are made more easy and extensive by the slight gliding of the carpal bones upon one another, and the comparatively free motion at the medio-carpal joint. The oblique direction of the fibres of the lateral

Fig. 233.—Front of Wrist with Anterior Annular Ligament.


Anterior radio-ulnar ligament
Internal lateral ligament of wrist with slip to annular ligament
PISIFORM
Anterior annular ligament
Anterior radio-carpal ligament
Tendon of the flexor carpi radialis

ligaments prevents any rotation at the radio-carpal joint, while it permits considerable freedom of abduction and adduction.

7. THE CARPAL JOINTS

The joints of the carpus may be subdivided into—

(*a*) The **joints of the first row.**
(*b*) The **joints of the second row.**
(*c*) The **medio-carpal,** or junction of the two rows with each other.

(*a*) The Union of the First Row of Carpal Bones

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The bones of the first row, the pisiform excepted, are united by two sets of ligaments and two interosseous fibro-cartilages.

Dorsal. Palmar.
Interosseous fibro-cartilages.

The **two dorsal ligaments** extend transversely between the bones, and connect the scaphoid with the semilunar, and the semilunar with the cuneiform. Their posterior surfaces are in contact with the posterior ligament of the wrist.

The **two palmar ligaments** extend nearly transversely between the bones connecting the scaphoid with the semilunar, and the semilunar with the cuneiform. They are stronger than the dorsal ligaments, and are placed beneath the anterior ligament of the wrist.

The **two interosseous fibro-cartilages** (fig. 235) are interposed between the scaphoid and semilunar, and the semilunar and cuneiform bones, reaching from the dorsal to the palmar surfaces, and being connected with the dorsal and palmar ligaments. They are narrow fibro-cartilages which extend between small portions only of the osseous surfaces. They help to form the convex carpal surface of the radio-carpal joint, and are somewhat wedge-shaped, their bases being towards the wrist, and their thin edges between the adjacent articular surfaces of the bones.

The **synovial membrane** is a prolongation from that of the medio-carpal joint.

The arterial and nerve-supplies are the same as for the medio-carpal joint.

The Union of the Pisiform Bone with the Cuneiform

This is an arthrodial joint which has a loose fibrous **capsule** attached to both the pisiform and cuneiform bones just beyond the margins of their articular surfaces. It is lined by a separate synovial membrane. Two strong rounded or flattened bands pass downwards from the pisiform, one to the process of the unciform, and the other to the base of the fifth metacarpal bone; these may be regarded as prolongations of the tendon of the *flexor carpi ulnaris*, and the pisiform bone may be looked upon in the light of a sesamoid bone developed in that tendon.

(*b*) The Union of the Second Row of Carpal Bones

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The four bones of this row are united by three dorsal, three palmar, and two interosseous ligaments.

The **three dorsal ligaments** (fig. 234) extend transversely and connect the trapezium with the trapezoid, the trapezoid with the magnum, and the magnum with the unciform.

The **three palmar ligaments** are stronger than the dorsal, and are deeply placed beneath the mass of extensor tendons; they extend transversely between the bones in a similar manner to the dorsal ligaments.

The **two interosseous ligaments** are situated on either side of the magnum, which they connect with the trapezoid on the outer, and the unciform on the inner, side. That between the magnum and trapezoid is attached to the apposed surfaces near their dorsal, i.e. the posterior aspect. That between the magnum and unciform (fig. 235) is attached to the apposed surfaces at their lower and anterior, i.e. their palmar aspect.

The **synovial membrane** is a prolongation of that lining the medio-carpal joint.

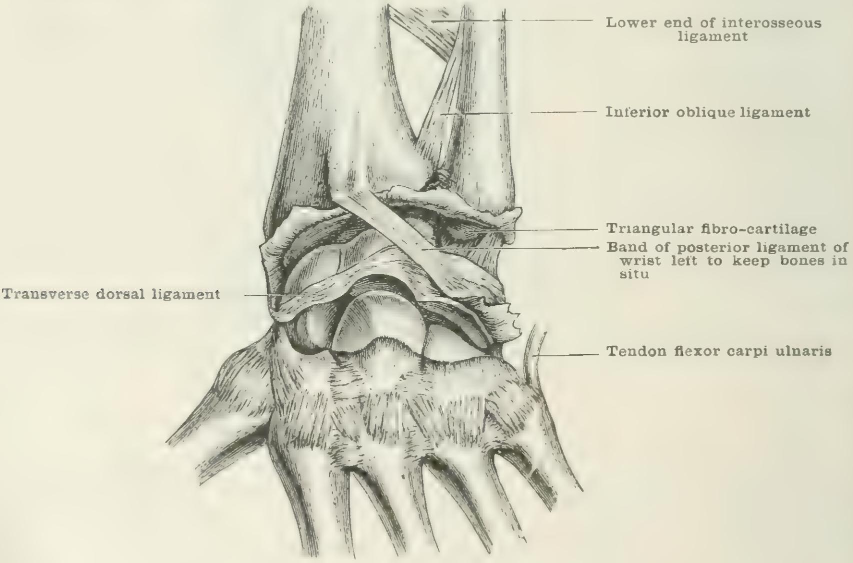
The arterial and nerve-supplies are the same as for the medio-carpal joint.

(c) The Medio-carpal Joint, or the Union of the Two Rows of the Carpus with each other

(I) **Class.**—*Diarthrosis.* **Subdivision.**—*Arthrodia.*
(II) **Class.**—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

The inferior surfaces of the bones of the first row are adapted to the superior articular surfaces of the bones of the second row. The line of this articulation is concavo-convex from side to side, and is sometimes described as having the course of a Roman **S** placed horizontally **∽**, a resemblance by no means strained. (i) The outer part of the first row consists of the scaphoid alone; it is convex, and bears the trapezium and trapezoid. (ii) Then follows a transversely elongated socket formed by the inner part of the scaphoid, the semilunar and cuneiform, into which are received (*a*) the head of the magnum, which articulates with the scaphoid and semilunar; (*b*) the upper and outer angle of the unciform, which articulates with the semilunar; and (*c*) the upper convex portion of the internal surface of the unciform, which articulates with the external and concave portion of the inferior surface of the cuneiform. (iii) The innermost part of the inferior surface of the cuneiform bone is convex, and turned a little backwards to fit into the lower portion of the internal surface of the unciform, which is a little concave and turned forwards to receive it. The central part, which forms a socket for the magnum and

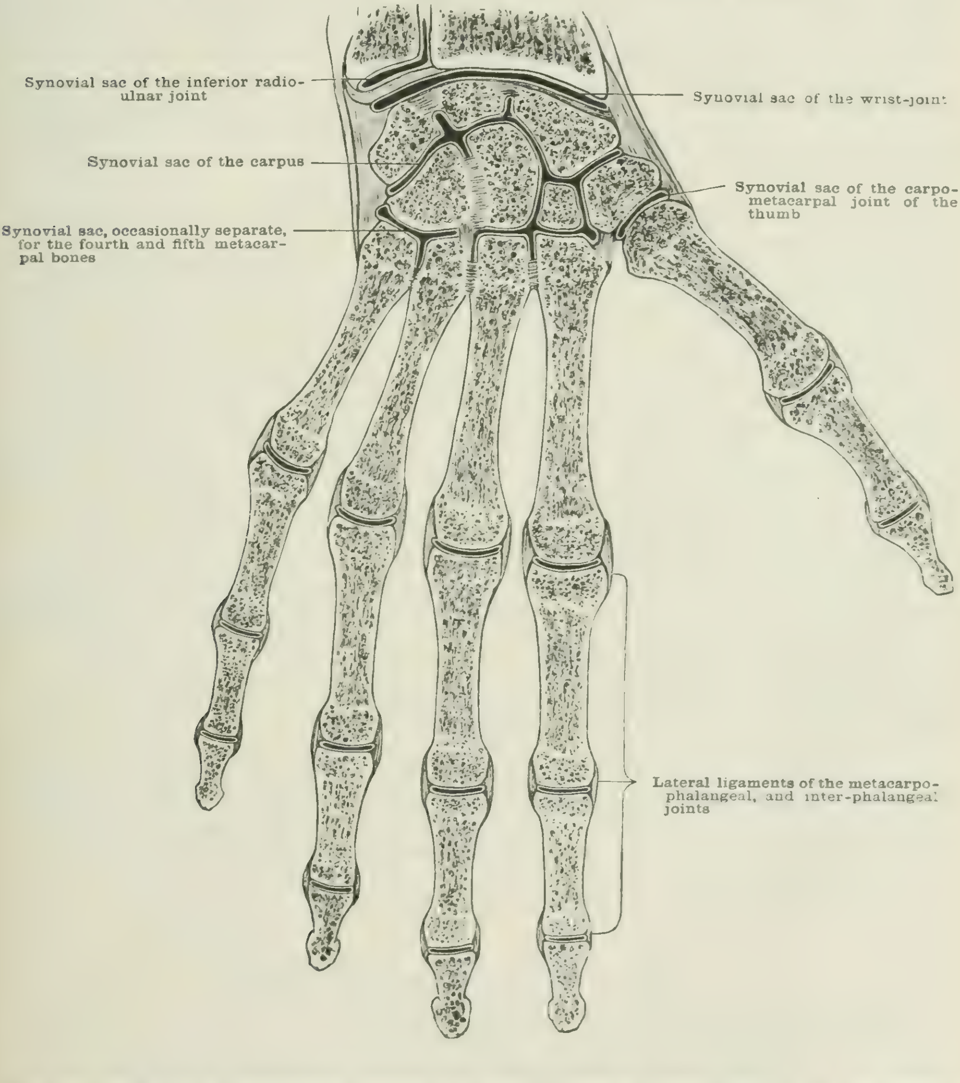
FIG. 234.—Posterior View of Wrist, with Capsule cut to show Articular Surfaces.


Lower end of interosseous ligament
Inferior oblique ligament
Triangular fibro-cartilage
Band of posterior ligament of wrist left to keep bones in situ
Transverse dorsal ligament
Tendon flexor carpi ulnaris

unciform, has somewhat the character of a condyloid joint, the os magnum and unciform being the condyle, to fit into the cavity formed by the scaphoid, semilunar, and cuneiform; the other portions are typically arthrodial. The ligaments are: (1) **anterior medio-carpal**; (2) **posterior medio-carpal**; (3) **transverse dorsal.**

The **anterior or palmar medio-carpal** is a ligament of considerable strength, consisting mostly of fibres which radiate from the magnum to the scaphoid, semilunar, and cuneiform; some few fibres connect the trapezoid and trapezium with the scaphoid, and others pass between the unciform and cuneiform. It is covered over and thickened by fibrous tissue derived from the sheaths of the flexor tendons and the fibres of origin of the small muscles of the thumb and little finger.

FIG. 235.—SYNOVIAL MEMBRANES OF WRIST, HAND, AND FINGERS.


Synovial sac of the inferior radio-ulnar joint
Synovial sac of the wrist-joint
Synovial sac of the carpus
Synovial sac of the carpo-metacarpal joint of the thumb
Synovial sac, occasionally separate, for the fourth and fifth metacarpal bones
Lateral ligaments of the metacarpo-phalangeal, and inter-phalangeal joints

The **posterior** or **dorsal medio-carpal ligament** consists of fibres passing obliquely from the bones of the first row to those of the second. It is stronger on the ulnar side than on the radial, but is not so strong as the palmar ligament.

The **transverse dorsal ligament** (fig. 234) is an additional band, well marked and often of considerable strength, which passes across the head of the magnum from the scaphoid to the cuneiform bone; besides binding down the head of the magnum, it serves to fix the upper and outer angle of the unciform in the socket formed by the first row.

The dorsal ligaments, like the palmar, are strengthened by a quantity of fibrous tissue belonging to the sheaths of the extensor tendons, and by an extension of some of the fibres of the capsule of the wrist. There are no proper lateral medio-carpal ligaments: they are but prolongations of the lateral ligaments of the wrist.

The **synovial membrane** (fig. 235) of the carpus is common to all the joints of the carpus, and extends to the bases of the four inner metacarpal bones. Thus, besides lining the inter- or medio-carpal joint, it sends two processes upwards between the three bones of the first row, and three downwards between the contiguous surfaces of the trapezoid and trapezium, the trapezoid and magnum, and magnum and unciform. From these latter, prolongations extend to the four inner carpo-metacarpal joints and the three intermetacarpal joints.

The **arterial supply** is derived from (*a*) the anterior and posterior carpal branches of the radial and ulnar arteries; (*b*) the carpal branch of the anterior interosseous; (*c*) the recurrent branches from the deep palmar arch. The terminal twigs of the anterior and posterior interosseous arteries supply the joint on its dorsal aspect.

The **nerve-supply** comes from the ulnar on the ulnar side, the median on the radial side, and the posterior interosseous behind.

The **movements** of the carpal articulations between bones of the same row are very limited and consist only of slight gliding upon one another; but, slight as they are, they give elasticity to the carpus to break the jars and shocks which result from blows or falls upon the hand.

The movements of one row of bones upon the other at the medio-carpal joint are more extensive, especially in the direction of flexion and extension, so that the hand enjoys a greater range of these movements than is permitted at the wrist-joint alone. At the wrist, extension is more free than flexion; but this is balanced by the greater freedom of flexion than of extension at the medio-carpal joint, and by flexion at the carpo-metacarpal joint, so that on the whole the range of flexion of the hand is greater than that of extension.

A slight amount of lateral motion accompanied by a limited degree of rotation also takes place; this rotation consists in the head of the magnum and the superior and outer angle of the unciform bone rotating in the socket formed by the three bones of the upper row, and in a gliding forwards and backwards of the trapezium and trapezoid upon the scaphoid.

In addition to the ligaments, the undulating outline and the variety of shapes of the apposed facets render this joint very secure.

Bearing in mind the mobility of this medio-carpal joint and of the carpo-metacarpal, we see at once the reason for the radial and ulnar flexors and extensors of the carpus being prolonged down to their insertion into the base of the metacarpus, for they produce the combined effect of motion at each of the three transverse articulations: (1) at the wrist; (2) at the medio-carpal; (3) at the carpo-metacarpal joints.

8. THE CARPO-METACARPAL JOINTS

These may be divided into two sets, namely:—

(*a*) The **carpo-metacarpal joints of the four inner fingers.**
(*b*) The **carpo-metacarpal joint of the thumb.**

The inferior surfaces of three of the bones of the second row of the carpus present a composite surface for the four inner metacarpal bones; the trapezium presents a distinct and separate saddle-shaped surface for the base of the metacarpal bone of the thumb.

(*a*) THE FOUR INNER CARPO-METACARPAL JOINTS

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

These joints exist between the trapezium, trapezoid, magnum, and unciform bones above, and the four inner metacarpal bones below. The ligaments which unite them are, dorsal, palmar, and interosseous.

The dorsal ligaments (fig. 234).—Three dorsal ligaments pass to the second metacarpal bone: one from each of the carpal bones with which it articulates, viz. the trapezium, trapezoid, and magnum. Two dorsal bands pass from the magnum to the third metacarpal bone. Two dorsal bands pass to the fourth bone: viz. one from the unciform, and another from the magnum; the latter is sometimes wanting. The fifth bone has only one band passing to it from the unciform.

The palmar ligaments (fig. 231).—One strong band passes from the second metacarpal bone to the trapezium internal to the ridge for the annular ligament; it is covered by the sheath of the *flexor carpi radialis.*

Three bands pass from the third metacarpal: one outwards to the trapezium, a middle one upwards to the magnum, and a third inwards over the fourth to reach the fifth metacarpal and the unciform bones.

One ligament connects the fourth bone to the unciform.

One ligament connects the fifth bone to the unciform, the fibres extending internally, and connecting the dorsal and palmar ligaments. The ligament to the fifth bone is strengthened in front by the prolonged fibres of the *flexor carpi ulnaris* and the strong inner slip of the ligament of the third metacarpal bone; and posteriorly, by the tendon of the *extensor carpi ulnaris.*

The **interosseous ligament** (fig. 235) is limited to one part of the articulation, and consists of short strong fibres connecting the contiguous angles of the unciform and magnum with the third and fourth metacarpal bones towards their palmar aspect. There is, however, a thick strong ligament connecting the edge of the trapezium with the outer border of the base of the second metacarpal bone; it helps to separate the carpo-metacarpal joint of the thumb from the common carpo-metacarpal joint, and to close in the radial side of the latter joint.

The **synovial membrane** is a continuation of the medio-carpal joint; occasionally there is a separate membrane between the unciform and fourth and fifth metacarpal bones (fig. 235); while that between the fourth and magnum is lined by the synovial sac of the common joint.

The **arteries** to the four inner carpo-metacarpal joints are as follows:—

(1) For the index finger: twigs, are supplied by the trunk of the radial on the dorsal and palmar aspects, the metacarpal, the dorsalis indicis, and the radialis indicis.

(2) For the middle finger: the metacarpal, first dorsal interosseous by the branch which passes upwards to join the posterior carpal arch, and a branch from the deep palmar arch which joins the anterior carpal arch.

(3) For the ring finger: the deep palmar arch and recurrent twigs from the second dorsal interosseous in the same manner as for the middle finger.

(4) For the little finger: the ulnar and its deep branch; also twigs from the second dorsal interosseous.

The **nerves** are supplied to these joints by the deep palmar branch of the ulnar, the posterior interosseous, and the median.

The **movements** permitted at these joints, though slight, serve to increase those of the medio-carpal and wrist-joints. The joint between the fifth metacarpal and the unciform bones approaches somewhat in shape and mobility the first carpo-metacarpal joint; it has a greater range of flexion and extension, but its lateral movement is nearly as limited as that of the three other metacarpal bones; the process of the unciform bone limits its flexion. Lateral motion towards the ulnar side is checked by the strong palmar band which unites the base of the fifth metacarpal to the base of the third, and the strong transverse ligament at the head of the bones. The mobility of the second, third, and fourth metacarpal bones is very limited, and consists almost entirely of a slight gliding upon the carpal bones, i.e. flexion and extension; that of the third and fourth bones is extremely slight, as there is no long flexor attached to either; but, owing to the close connection of the bases of the metacarpal bones, the radial and ulnar flexors and extensors of the carpus act on all by their pull on the particular bone into which they are inserted.

Abduction, or movement toward the radial side, is prevented by the impaction of the second bone against the trapezium; a little adduction is permitted, and is favoured by the slope given to the unciform and fifth metacarpal bones.

There is also a slight gliding between the fourth and fifth bones, when the concavity they present towards the palm is deepened to form the 'cup of Diogenes.'

(*b*) The Carpo-metacarpal Joint of the Thumb

Class.—*Diarthrosis.* **Subdivision.**—*Saddle-shaped Arthrodia.*

The bones entering into this joint are the base of the first metacarpal, and the trapezium. The first metacarpal bone diverges from the other four, contrasting very strongly with the position of the great toe. It is due to this divergence that the thumb is able to be opposed to each and all the fingers. The ligament which unites the bones is the

Capsular.

The **capsular ligament** (figs. 231 and 232) consists of fibres which pass from the margin of the articular facet on the trapezium, to the margin of the articular facet at the base of the first metacarpal bone. The fibres are stronger on the dorsal than on the palmar aspect. They are not tense enough to hold the bones in close contact, so that while they restrict they do not prevent motion in any direction. The internal fibres are stronger than the external.

The **synovial membrane** is lax, and distinct from the other synovial membranes of the carpus.

The **arteries** of the carpo-metacarpal joint of the thumb are derived from the trunk of the radial, the arteria princeps pollicis, and the dorsales pollicis.

The **nerves** are supplied by the branches of the median to the thumb.

The **movements** of this joint are regulated by the shape of the articular surfaces, rather than by the ligaments, and consist of flexion, extension, abduction, adduction, and circumduction, but not rotation. In flexion and extension the metacarpal bone slides to and fro upon the trapezium; in abduction and adduction it slides from side to side or, more correctly, revolves upon the antero-posterior axis of the joint. The power of opposing the thumb to any of the fingers is due to the forward and inward obliquity of its flexion movement, which is by far its most extensive motion. Abduction is very free, while adduction is limited on account of the proximity of the second metacarpal bone. The movement of the trapezium upon the rest of the carpus somewhat increases the range of all the movements of the thumb.

9. THE INTERMETACARPAL ARTICULATIONS

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The metacarpal of the thumb is not connected with any other metacarpal bone. The second, third, fourth, and fifth metacarpal bones are in actual contact at their bases, and are held firmly together by the following ligaments:—

Dorsal. Palmar.
Interosseous ligaments.

The **dorsal ligaments** (fig. 233) are layers of variable thickness of strong, short fibres, which pass transversely from bone to bone, filling up the irregularities on the dorsal surfaces.

The **palmar ligaments** are transverse layers of ligamentous tissue passing from bone to bone; they cannot be well differentiated from the other ligaments and fibrous tissue covering the bones.

The **interosseous ligaments** (fig. 235) pass between the apposed surfaces of the bones, and are attached to the distal sides of the articular facets, so as to close in the synovial cavities on this aspect; where there are two articular facets, the fibres extend upwards between them, nearly as far as their carpal facets. That between the fourth and fifth is the weakest.

The **arteries** to the intermetacarpal joints are twigs from the palmar and dorsal interosseous arteries; the twigs pass upwards between the interosseous muscles.

The **nerves** are derived from the ulnar and the posterior interosseous.

The **synovial membrane** is prolonged downwards from the common carpal sac.

The Union of the Heads of the Metacarpal Bones

The distal extremities of these bones are connected together on their palmar aspects by what is called the **transverse ligament.** This consists of three short bands of fibrous tissue, which unite the second and third, third and fourth, and the fourth and fifth bones. They are rather more than a quarter of an inch (6 mm.) deep, and rather less in width, and limit the distance to which the metacarpal bones can be separated. They are continuous above with the fascia covering the interosseous muscles; below, they are connected with the subcutaneous tissue of the web of the hand. They are on a level with the front surfaces of the bones, and are blended on either side with the edges of the glenoid ligament in front, with the lateral ligaments of the metacarpo-phalangeal joint, and also with the sheaths of the tendons. In front, a *lumbrical* muscle passes with the digital arteries and nerves; while behind, the *interossei* muscles pass to their insertions.

10. THE METACARPO-PHALANGEAL JOINTS

(*a*) The Metacarpo-phalangeal Joints of the Four Inner Fingers

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

In these joints the cup-shaped extremity of the base of the first phalanx fits on to the rounded head of the metacarpal bone, and is united by the following ligaments:—

Lateral. Glenoid.

The **glenoid ligament** (fig. 236) is a fibro-cartilaginous plate which seems more intended to increase the depth of the phalangeal articular facet in front, than to unite the two bones. It is much more firmly attached to the margin of the phalanx than to the metacarpal bone, being only loosely connected with the palmar surface of the latter by some loose areolar tissue which covers in the synovial sac, here prolonged upon the surface of the bone some little distance. Laterally, it is connected with the lateral ligaments and the transverse metacarpal ligament. It corresponds to the sesamoid bones of the thumb; a sesamoid bone sometimes exists at the inner border of the joint of the little finger.

The **lateral ligaments** (figs. 235 and 236) are strong and firmly connect the bones with one another; each is attached above to the lateral tubercle, and to a depression in front of the tubercle, of the metacarpal bone. From this point the fibres spread widely as they descend on the side of the base of the phalanx; the anterior fibres are connected with the glenoid ligament; the posterior blend with the tendinous expansion at the back of the joint.

The joint is covered in **posteriorly** by the expansion of the extensor tendon, and some loose areolar tissue passing from its under surface to the bones (fig. 236).

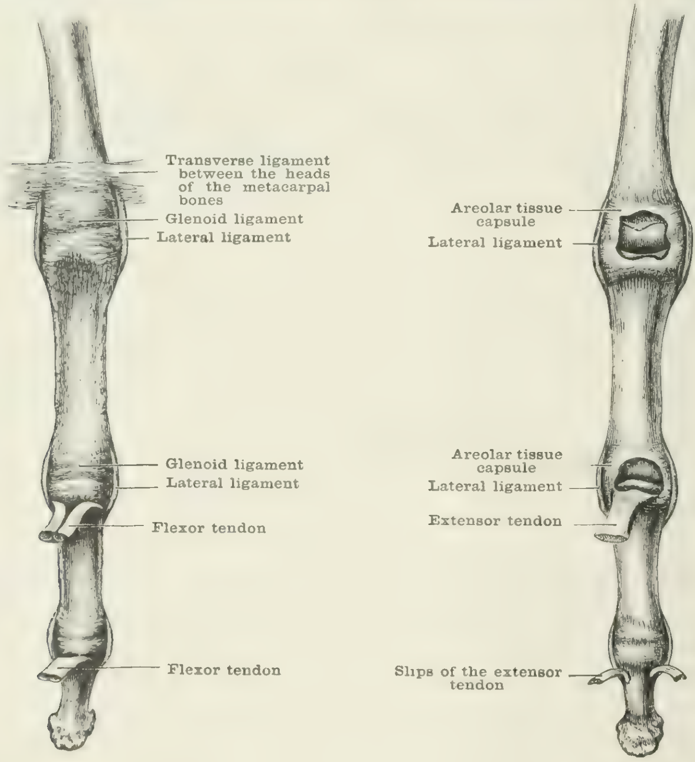
The **synovial sac** is loose and capacious, more especially over the base of the phalanx behind, and the head of the metacarpal bone in front.

The **arteries** come from the digital or anterior interosseous vessels of the deep arch.

The **nerves** are derived from the digital branches, or from twigs of the branches of the ulnar to the interosseous muscles.

The **movements** permitted at these joints are: flexion, extension, abduction, adduction, and circumduction. Flexion is the most free of all, and may be continued until the phalanx is at a right angle with the metacarpal bone. It is on this account that the articular surface of the head of the bone is prolonged so much further on the palmar aspect, and that the synovial sac is here so loose and ample. Extension is the most limited of the movements, and can only be carried to a little beyond the straight line. Abduction and adduction are fairly free, but not so free as flexion. Flexion is associated with adduction, and extension with abduction. This may be proved by opening the hand, when the fingers involuntarily separate as they extend, while in closing the fist they come together again. The free abduction, adduction, and circumduction which are permitted at these joints are due to the fact that the long axes of the articular facets are at right angles to one another.

FIG. 236.—ANTERIOR AND POSTERIOR VIEW OF LIGAMENTS OF THE FINGERS.


Transverse ligament between the heads of the metacarpal bones
Glenoid ligament
Lateral ligament
Glenoid ligament
Lateral ligament
Flexor tendon
Flexor tendon
Areolar tissue capsule
Lateral ligament
Areolar tissue capsule
Lateral ligament
Extensor tendon
Slips of the extensor tendon

(*b*) THE METACARPO-PHALANGEAL JOINT OF THE THUMB

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

The head of the metacarpal bone of the thumb differs considerably from the corresponding ends of the metacarpal bones of the fingers. It is less convex, wider from side to side, the palmar edge of the articular surface is raised and irregular, and here on either side of the median line are the two facets for the sesamoid bones. The base of the first phalanx of the thumb, too, is more like the base of the second phalanx of one of the other fingers. The ligaments are:—

Lateral. Posterior.
Sesamoid bones in place of a glenoid ligament.

The **lateral ligaments** are short, strong bands of fibres, which radiate from depressions on either side of the head of the metacarpal bone to the base of the first phalanx and sesamoid bones. As they descend they pass a little forwards, so that the greater number are inserted in front of the centre of motion.

The **posterior ligament** consists of scattered fibres which pass across the joint from one lateral ligament to the other, completing the capsule and protecting the synovial sac.

The **sesamoid bones** are two in number, situated on either side of the middle line, and connected together by strong transverse fibres which form the floor of the groove for the *long flexor tendon;* they are connected with the base of the phalanx and head of the metacarpal bone by strong fibres. Anteriorly they give attachment to the short muscles of the thumb, and posteriorly are smooth for the purpose of gliding over the facets. The lateral ligaments are partly inserted into their sides.

The **arteries** and **nerves** come from the digital branches of the thumb.

The **movements** are chiefly flexion and extension, very little lateral movement being permitted, and that only when the joint is slightly bent. Thus this joint more nearly approaches the simple hinge character than the corresponding articulations of the fingers. The thumb gets its freedom of motion at the carpo-metacarpal joint; the fingers get theirs at the metacarpo-phalangeal, but they are not endowed with so much freedom as the thumb enjoys.

11. THE INTERPHALANGEAL ARTICULATIONS

Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

The ligaments which unite the phalanges of the thumb and of the fingers are:—

Glenoid. Lateral.

The **glenoid ligament** (fig. 236), sometimes called the sesamoid body, is very firmly connected with the base of the distal bone, and loosely, by means of fibro-areolar tissue, with the head of the proximal one. It blends with the lateral ligaments at the sides, and over it pass the flexor tendons. Occasionally a sesamoid bone is developed in the cartilage of the interphalangeal joint of the thumb.

The **lateral ligaments** (figs. 235 and 236) are strong bands which are attached to the rough depressions on the sides of the upper phalanx, and to the projecting lateral margins of the lower phalanx of each joint. They are tense in every position, and entirely prevent any lateral motion; they are connected posteriorly with the expansion of the extensor tendon.

Posteriorly (fig. 236) the joint is covered in by the deep surface of the extensor tendon, and a little fibro-areolar tissue extends from the tendon, and thickens the posterior portion of the synovial sac, completing the capsule.

The **synovial membrane** is loose and ample, and extends upwards a little way along the shaft of the proximal bone.

The **arteries** and **nerves** come from their respective digital branches.

The **movements** are limited to flexion and extension. Flexion is more free, and can be continued till one bone is at a right angle to the other, and is most free at the junction of the first and second bones; the second phalanx can be flexed on the first through 110° to 115° when the latter is not flexed. The greater freedom of flexion is due to the greater extent of the articular surface in front of the heads of the proximal bones, and to the direction of the fibres of the lateral ligaments, which pass a little forwards to their insertion into the distal bone.

THE ARTICULATIONS OF THE LOWER LIMB

The articulations of the lower limb are the following:—

1. The **hip-joint.**
2. The **knee-joint.**
3. The **tibio-fibular union.**
4. The **ankle-joint.**
5. The **tarsal joints.**
6. The **tarso-metatarsal joints.**
7. The **intermetatarsal joints.**
8. The **metatarso-phalangeal joints.**
9. The **interphalangeal joints.**

1. THE HIP-JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Enarthrodia.*

The hip is the most typical example of a ball-and-socket joint in the body, the round head of the femur being received into the cup-shaped cavity of the acetabulum. Both articular surfaces are coated with cartilage, that covering the head of the femur being thicker above where it has to bear the weight of the body, and thinning out to a mere edge below; the pit for the ligamentum teres is the only part uncoated, but the cartilage is somewhat heaped up around its margin. Covering the acetabulum, the cartilage is horseshoe-shaped, and thicker above than below, being deficient over the depression at the bottom of the acetabulum, where a mass of fatty tissue—the so-called synovial or Haversian gland—is lodged.

The ligaments of the joint are:—

Capsular.
Transverse.
Ligamentum teres.
Cotyloid cartilage.

The **capsular ligament** is one of the strongest ligaments in the body. It is large and somewhat loose, so that in every position of the body some portion of it is relaxed. At the **pelvis** it is attached, superiorly, to the base of the anterior inferior iliac spine; curving backwards, it becomes blended with the deep surface of the reflected tendon of the *rectus femoris;* posteriorly, it is attached a few lines from the acetabular rim; and below, to the upper edge of the groove between the acetabulum and tuberosity of the ischium. Thus it reaches the transverse ligament, being firmly blended with its outer surface, and frequently sends fibres beyond the notch to blend with the obturator membrane. Anteriorly it is attached to the pubes near the notch, to the pectineal eminence, and thence backwards to the base of the iliac spine. A thin strong stratum is given off from its superficial aspect behind; this extends beneath the gluteus minimus, and small rotators, to be attached above to the dorsum of the ilium higher than the reflected tendon of the rectus, and posteriorly to the ilium and ischium nearly as far as the sciatic notch. As this expansion passes over the long tendon of the *rectus*, the tendon may be described as being in part contained within the substance of the capsule.

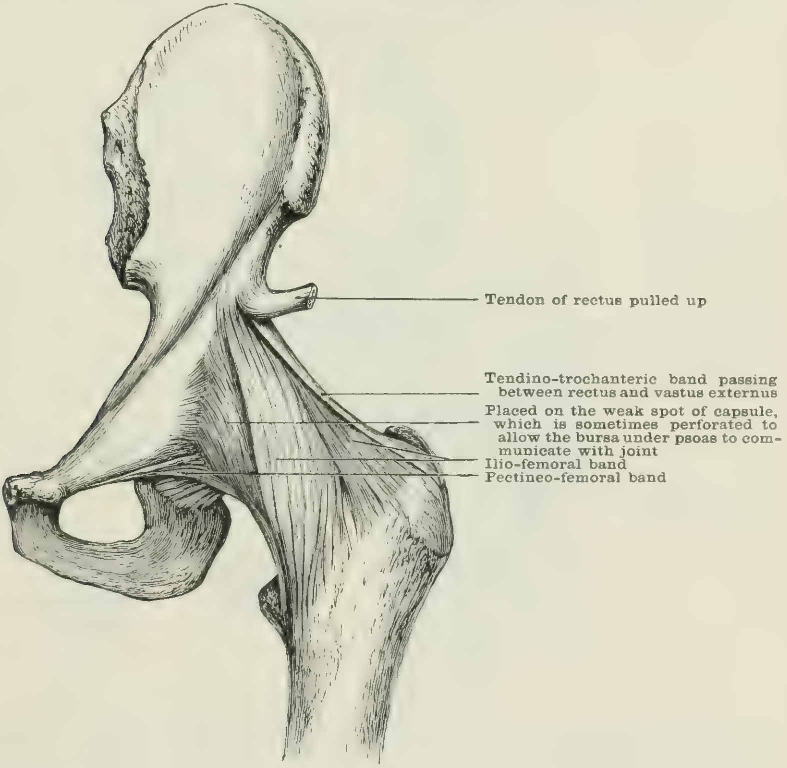
At the **femur**, the capsular ligament is fixed to the anterior portion of the upper border of the great trochanter, and to the superior cervical tubercle. Thence it runs down the spiral line as far as the inner border of the femur, where it is on a level with the lower part of the lesser trochanter. It then runs upwards and backwards along an oblique line about two-thirds of an inch (1·6 cm.) in front of the lesser trochanter, and continues its ascent along the back of the neck nearly parallel to the posterior intertrochanteric line, and from one-half to two-thirds of an inch (12 to 16 mm.) above it; finally, it passes along the inner side of the digital fossa to reach the anterior superior angle of the great trochanter.

On laying open the capsule, some of the deeper fibres are seen reflected upwards along the neck of the femur, to be attached much nearer the head: these are the **retinacula.** One corresponds to the upper, and another to the lower part of the spiral line; a third is seen at the upper and back part of the neck. They form flat bands, which lie on the femoral neck.

Superadded to the capsule, and considerably strengthening it, are three auxiliary bands, whose fibres are intimately blended with, and in fact form part of, the capsule, viz. the ilio-femoral, ischio-femoral, and pectineo-femoral bands.

The **ilio-femoral** (fig. 237) is the longest, widest, and strongest of the bands. It is of triangular shape, with the apex attached above to a curved line on the ilium immediately below and behind the anterior inferior spine, and its base below to the anterior edge of the greater trochanter and to the spiral line as far as the inner border of the shaft. The highest or outermost fibres are coarse, almost straight, and shorter than the rest; the innermost fibres are also thick and strong, but oblique. This varying obliquity of the fibres, and their accumulation at the borders, explain why this band has been described as the Y-shaped ligament. About the centre of its base, near the femoral attachment, is an aperture transmitting an articular twig from the transverse branch of the external circumflex artery.

FIG. 237.—ANTERIOR VIEW OF THE CAPSULE OF THE HIP-JOINT.

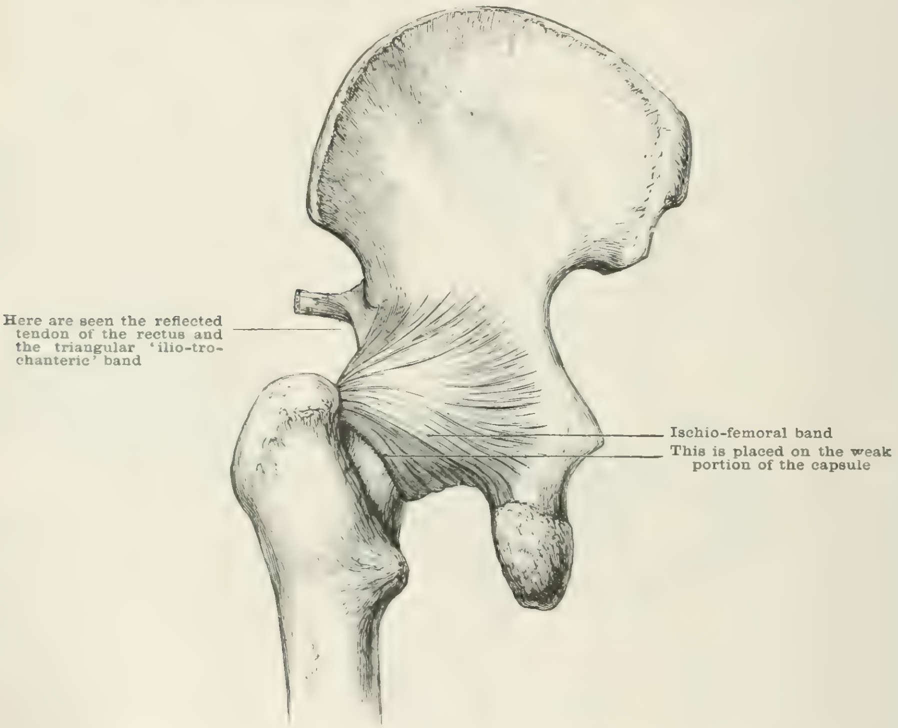

Tendon of rectus pulled up
Tendino-trochanteric band passing between rectus and vastus externus
Placed on the weak spot of capsule, which is sometimes perforated to allow the bursa under psoas to communicate with joint
Ilio-femoral band
Pectineo-femoral band

The **ischio-femoral band** (fig. 238) is formed of very strong fibres attached all along the upper border of the groove for the external obturator, and to the ischial margin of the acetabulum above the groove. The highest of these incline a little upwards as they pass outwards to be fixed to the greater trochanter in front of the insertion of the pyriformis tendon, while the other fibres curve more and more upwards as they pass outwards to their insertion at the inner side of the digital fossa, blending with the insertion of the external rotator tendons. When the joint is in flexion these fibres pass in nearly straight lines to their femoral attachment, and spread out uniformly over the head of the femur; but in extension they wind over the back of the femur in a zonular manner, embracing the posterior aspect of the neck of the femur.

The **pectineo-femoral band** (fig. 237) is a distinct but narrow set of fibres which are individually less marked than the fibres of the other two bands; they are fixed above to the anterior border of the pectineal eminence, reaching as far down as the pubic end of the cotyloid notch. Below, they reach the neck of the femur, and are fixed above and behind the lowermost fibres of the ilio-femoral band, with which they blend.

In thickness and strength the capsule varies greatly; thus, if two lines be drawn, one from the anterior inferior spine to the inner border of the femur near the lesser trochanter, and the other from the anterior part of the groove for the external obturator to the digital fossa, all the ligament between these lines on the outer and upper aspects of the joint is very thick and strong, while that below and to the inner side, except at the narrow pectineo-femoral band, is thin and weak, so that the head of the bone can be seen through it. The capsule is thickest in the course of the ilio-femoral band, towards the outer part of which it measures over a quarter of an inch (6 mm.). Between the ilio-femoral and ischio-femoral bands the capsule is very strong, and with it here, near the acetabulum is incorporated the reflected tendon of the rectus, and here also a triangular band of fibres runs downwards and forwards to be attached by a narrow insertion to the ridge on the front border of the greater trochanter near the gluteus minimus (the **ilio-trochanteric band**) (fig. 238).

Fig. 238.—Posterior View of the Capsule of the Hip-joint.

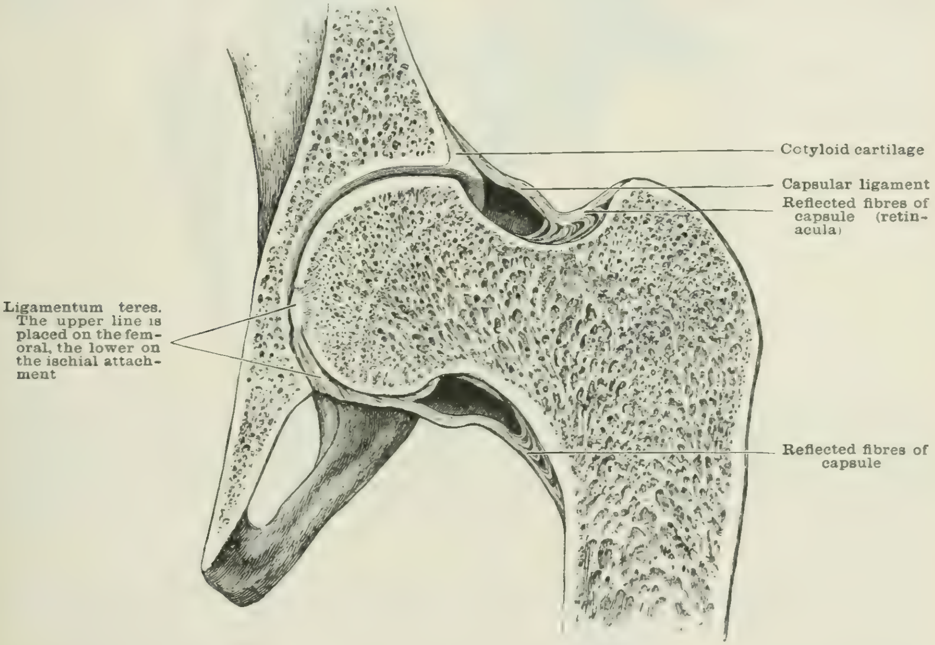

Here are seen the reflected tendon of the rectus and the triangular 'ilio-trochanteric' band
Ischio-femoral band
This is placed on the weak portion of the capsule

The capsule is strengthened also at this point by a strong band from the under surface of the gluteus minimus, and by the **tendino-trochanteric band** which passes down from the reflected tendon of the rectus to the vastus externus (fig. 237). This is closely blended with the capsule near the outer edge of the ilio-femoral ligament.

The thinnest part of the capsule is between the pectineo-femoral and ilio-femoral bands; this is sometimes perforated, allowing the bursa under the psoas to communicate with the joint. The capsule is also very thin at its attachment to the back of the femoral neck, and again opposite the cotyloid notch.

The **ligamentum teres** (figs. 239 and 240) is an interarticular flat band which extends from the acetabular notch to the head of the femur, and is usually about an inch and a half (3·7 cm.) long. It has two bony attachments, one on either side of the cotyloid notch immediately below the articular cartilage, while intermediate fibres spring from the under surface of the transverse ligament. The ischial portion is the stronger, and has several of its fibres arising outside the cavity, below and in connection with the origin of the transverse ligament, where it is also continuous with the capsule and periosteum of the ischium. At the femur it is fixed to the front part of the depression on the head, and to the cartilage round the margin of the depression. It is covered by a prolongation of synovial membrane, which also covers the cushion of fat in the recess of the acetabulum; the portion of the membrane reflected over the fatty tissue does not cling closely to the round ligament, but forms a triangular fold, the apex of which is at the femur.

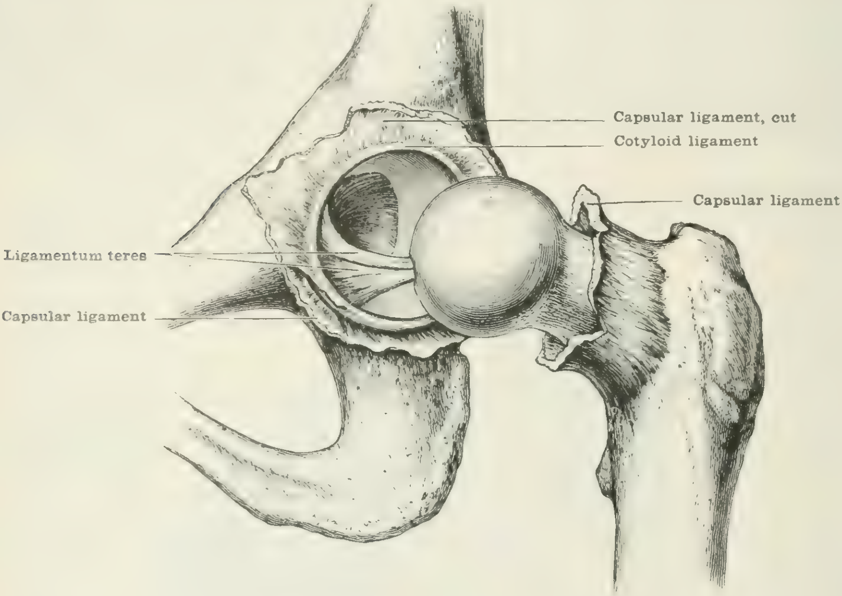
Fig. 239.—Section through the Hip-joint, showing the Cotyloid Ligament, Ligamentum Teres, and Retinacula.


Cotyloid cartilage
Capsular ligament
Reflected fibres of capsule (retinacula)
Ligamentum teres. The upper line is placed on the femoral, the lower on the ischial attachment
Reflected fibres of capsule

The **transverse ligament** (fig. 241) passes across the cotyloid notch and converts it into a foramen; it supports part of the cotyloid fibro-cartilage, and is connected with the ligamentum teres and the capsule. It is composed of decussating fibres, which arise from the margin of the acetabulum on either side of the notch, those coming from the pubes being more superficial, and passing to form the deep part of the ligament at the ischium, while those superficial at the ischium are deep at the pubes. It thus completes the rim of the acetabulum.

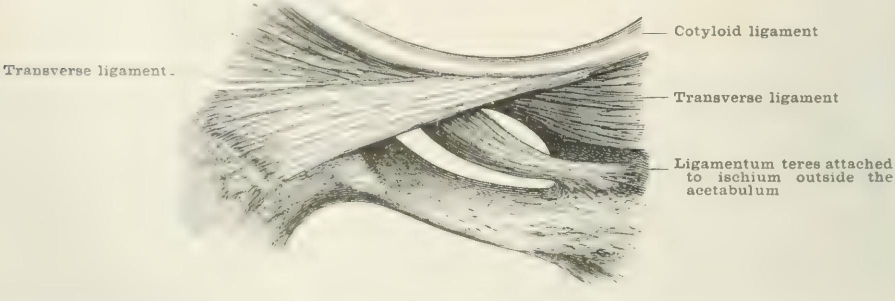
The **cotyloid fibro-cartilage** (figs. 239 and 240) is a yellowish-white structure, which deepens the acetabulum by surmounting its margin. It varies in strength and thickness, but is stronger at its iliac and ischial portions than elsewhere. Its base is broad and fixed to the bony rim as well as to the articular cartilage of the acetabulum on the inner, and the periosteum on the outer side of it, and blends inseparably with the transverse ligament which supports it over the cotyloid notch. Its free margin is thin; on section it is somewhat lunated, having its outer surface convex and its articular face concave and very smooth in adaptation to the head of the bone, which it tightly embraces a little beyond its greatest circumference. It somewhat contracts the aperture of the acetabulum, and retains the head of the femur within its grasp after division of the muscles and capsular ligament. It is covered on both aspects by synovial membrane.

Fig. 240.—Hip-joint after dividing the Capsular Ligament and disarticulating the Femur.


Capsular ligament, cut
Cotyloid ligament
Capsular ligament
Ligamentum teres
Capsular ligament

The **synovial membrane** lines the capsule and both surfaces of the cotyloid ligament, and passes over the border of the acetabulum to reach and cover the fatty cushion it contains. The part covering the fatty cushion is unusually thick, and is attached round the edges of the rough bony surface on which the cushion rests. The membrane is loosely reflected off this on to the ligamentum teres, along which it is prolonged to the head of the femur; thus the fibres of the round ligament are shut out from the joint cavity. From the capsule the synovial membrane is also reflected below on to the neck of the femur, whence it passes over the retinacula to the margin of the articular cartilage. A fold of synovial membrane on the under aspect of the neck often conveys to the head of the femur a branch of artery—generally a branch of the internal circumflex.

Fig. 241.—Portions of Ischium and Pubes, showing the Cotyloid Notch and the Ligamentum Teres attached outside the Acetabulum.


Transverse ligament
Cotyloid ligament
Transverse ligament
Ligamentum teres attached to ischium outside the acetabulum

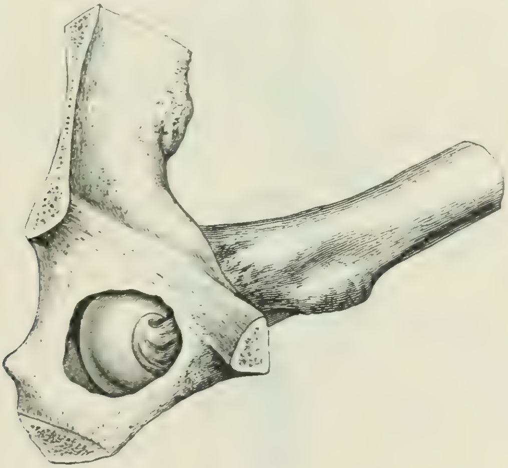
The **arterial supply** comes from (*a*) the transverse branches of the internal and external circumflex arteries; (*b*) the external branch of the obturator sends a branch through the cotyloid notch beneath the transverse ligament, which ramifies in the fat at the bottom of the acetabulum, and travels down the round ligament to the head of the femur; (*c*) the inferior branch of the deep division of the gluteal; and (*d*) the sciatic arteries. The branch from the obturator to the ligamentum teres is sometimes very large when the branch from the internal circumflex does not also supply the ligament.

The gluteal and sciatic send several branches through the innominate attachment of the capsular ligament: these anastomose freely beneath the capsule around the outer aspect of the acetabulum, and supply some branches to enter the bone, and others which enter the substance of the cotyloid ligament. There is quite an arterial crescent upon the posterior and postero-superior portions of the acetabulum; but no vessels are to be seen on the inner aspect of the cotyloid ligament.

The **nerve-supply** comes from (*a*) anterior crural, (*b*) anterior division of the obturator, (*c*) the accessory obturator, and (*d*) the sacral plexus, by a twig from the nerve to the quadratus femoris, or from the upper part of the great sciatic, or from the lower part of the sacral plexus.

The **muscles** in relation with the hip-joint are: **in front**, the *psoas*, which is separated from the capsule by a bursa, and the *iliacus*, which in part arises from the capsule; **above** are the straight and reflected tendons of the *rectus*, the reflected tendon being enclosed between the fibres of the capsule, and a band which passes down from the reflected tendon to the vastus externus; also the *gluteus minimus*, which is closely adherent to the capsule; **above** and **behind** are the *pyriformis*, which sometimes sends a slip into the capsule; the *internal obturator*, which acts as a powerful strap to the back of the joint, and the two *gemelli*; **below** and **behind** is the *external obturator*, passing over the capsule, whilst a dense band of fibro-cellular tissue connects the sheath of the obturator externus with the capsule along the posterior edge of the muscle; **internally** is the *pectineus*.

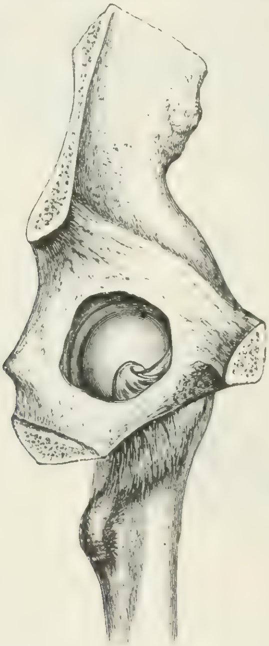
FIG. 242.—LIGAMENTUM TERES, LAX IN FLEXION.



The movements.—The hip-joint, like the shoulder, is a ball-and-socket joint, but with a much more complete socket and a corresponding limitation of movement. Each variety of movement is permitted, viz. flexion, extension, abduction, adduction, circumduction, and rotation; and any two or more of these movements not being antagonistic can be combined, i.e. flexion or extension associated with abduction or adduction can be combined with rotation in or out.

It results from the obliquity of the neck of the femur that the movements of the head in the acetabulum are always more or less of a rotatory character. This is more especially the case during flexion and extension, and two results follow from it. First, the bearing surfaces of the femur and acetabulum preserve their apposition to each other, so that the amount of articular surface of the head in the acetabulum does not sensibly diminish *pari passu* with the transit of the joint from the extended to the flexed position, as would necessarily be the case if the movement of the femoral head, like that of the thigh itself, was simply angular, instead of rotatory and angular. Secondly, as rotation of the head can continue until the ligaments are tight without being checked by contact of the neck of the thigh bone with the rim of the acetabulum, flexion of the thigh so far as the joint is concerned is practically unlimited. Flexion is the most important, most frequent, and most extensive movement, and in the dissected limb, before the ligaments are disturbed, can be carried to 160°, and is then checked by the lower fibres of the ischio-femoral ligament. In the living subject simple flexion can continue until checked by the contact of the soft parts at the groin, if the knee be bent; if the knee be straight, flexion of the hip is checked in most persons by the hamstring muscles at nearly a right angle. This is very evident on trying to touch the ground with the fingers without bending the knees, the chief strain being felt at the popliteal space. This is due to the shortness of the hamstrings. Extension is limited by the ilio-femoral ligament.

Fig. 213.—Ligamentum Teres, very lax in complete Extension.



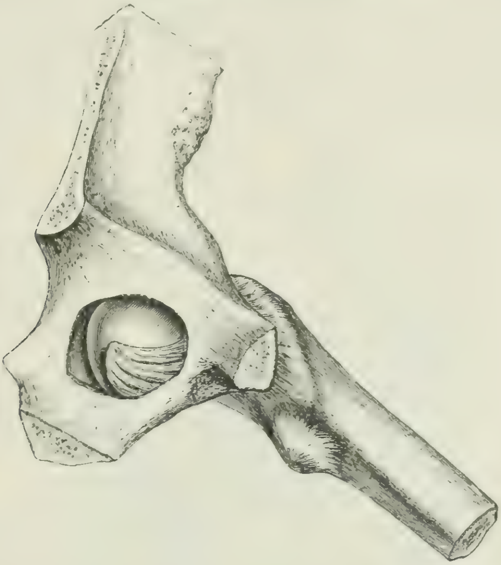
Abduction and outward rotation can be performed freely in every position of flexion and extension—abduction being limited by the pectineo-femoral ligament; outward rotation by the ilio-femoral ligament, especially its inner portion, during extension; but by the outer portion, as well as by the ligamentum teres, during flexion.

Adduction is very limited in the extended thigh on account of the contact with the opposite limb. In the slightly flexed position adduction is more free than in extension, and is then limited by the outer fibres of the ilio-femoral band and the superior portion of the capsule. In flexion the range is still greater, and limited by the ischio-femoral ligament, the ligamentum teres being also rendered nearly tight. Inward rotation in the nearly extended position is limited by the ilio-femoral ligament; and in flexion by the ischio-femoral ligament and the portion of the capsule between it and the ilio-femoral band.

The ilio-femoral band also prevents the tendency of the trunk to roll backwards on the thigh bones in the erect posture, and so does away with the necessity for muscular power for this purpose; it is put on stretch in the stand-at-ease position.

The ligamentum teres is of little use in resisting violence or in imparting strength to the joint. It assists in checking rotation outwards, and adduction during flexion. A ligament can only be of use when it is tight, and it was found by trephining the bottom of the acetabulum, removing the fat, and threading a piece of whipcord round the ligament, that the ligament was slack in simple flexion, and very loose in complete extension, but that its most slack condition was in abduction. It is tightest in flexion combined with adduction and rotation outwards, and almost as tight in flexion with outward rotation alone, and in flexion with adduction alone (figs. 242 to 244).

FIG. 244.—LIGAMENTUM TERES, DRAWN TIGHT IN FLEXION COMBINED WITH ROTATION OUTWARDS AND ADDUCTION.



2. THE KNEE-JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

The knee is the largest joint in the body. It is rightly described as a ginglymoid joint, but there is also an arthrodial element; for, in addition to flexion and extension, there is a sliding backwards and forwards of the tibia upon the femoral condyles, as well as slight rotation round a vertical axis. It is one of the most superficial, and, as far as adaptation of the bony surfaces goes, one of the weakest joints, for in no position are the bones in more than partial contact. Its strength lies in the number, size, and arrangement of the ligaments, and the powerful muscles and fascial expansions which pass over the articulation and enable it to withstand the leverage of the two longest bones in the body. It may be said to consist of two articulations with a common synovial membrane—the patello-femoral and the tibio-femoral, the latter being double. It is composed of the condyles and trochlear surface of the femur, the tuberosities of the tibia, and the patella, united by the following ligaments, which may be divided into an external and internal set:—

EXTERNAL

(1) Fibrous expansion of the extensors.
(2) Capsular or anterior ligament.
(3) Posterior ligament.
(4) External lateral.
(5) Internal lateral.
(6) Ligamentum patellæ.

INTERNAL

(1) Anterior crucial.
(2) Posterior crucial.
(3) Internal semilunar fibro-cartilage.
(4) External semilunar fibro-cartilage.
(5) Coronary.
(6) Transverse.

EXTERNAL LIGAMENTS

Superficial to the fibrous expansion of the quadriceps extensor tendons the fascia lata of the thigh covers the front and sides of the knee-joint.

The deep fascia of the thigh, as it descends to its attachment to the tubercle and oblique lines of the tibia, not only overlies but blends with the fibrous expansion of the extensor tendons.

The oblique lines of the tibia curve upwards and backwards from the tubercle on each side to the postero-lateral part of the tuberosities. The process of fascia attached to the outer ridge of the tibia and to the head of the fibula, descends from the tensor vaginæ femoris and is very thick and strong. It is firmly blended with the tendinous fibres of the vastus externus. The fascia lata, on the inner side of the patella, besides being attached to the inner oblique ridge of the tibia, sends some longitudinal fibres lower down to become blended with the fibrous expansion of the sartorius. The fascia is much thinner on the inner side of the patella than on the outer, and blends much less with the tendon of the vastus internus than the outer part of the fascia does with the vastus externus. A thin layer of the fascia lata in the form of transverse or arciform fibres passes over the front of the joint. These fibres are specially well marked over the ligamentum patellæ, and blend here with the central portion of the quadriceps extensor fibres.

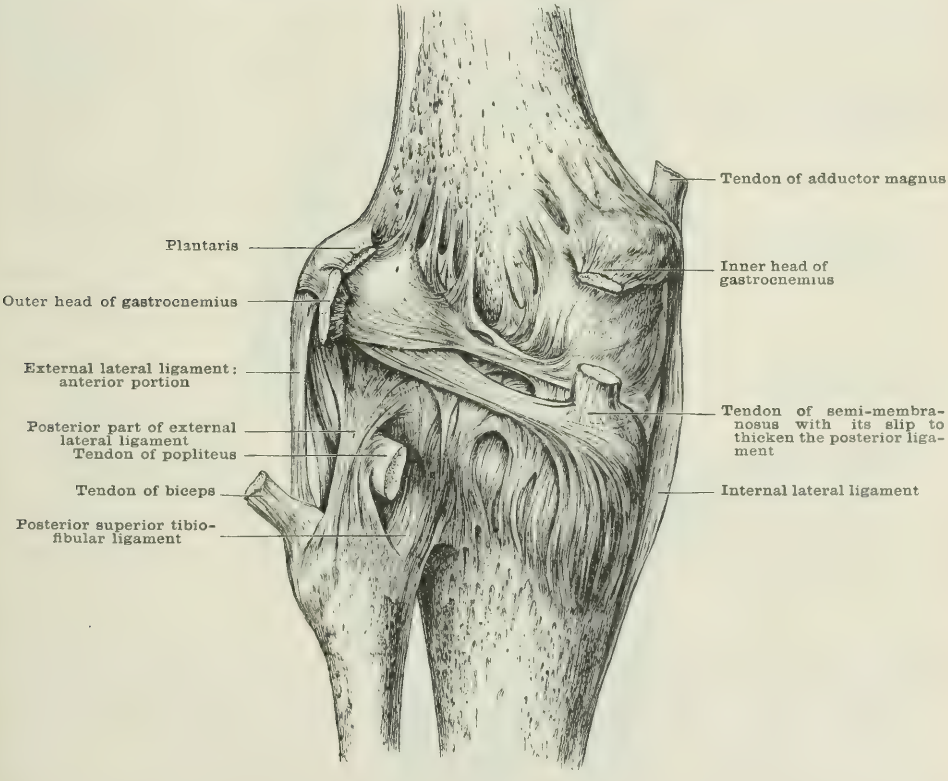
The **fibrous expansion of the extensor tendons** consists (1) of a central portion, densely thick and strong, an inch and a half (3·7 cm.) broad, which is inserted into the anterior two-thirds of the upper border of the patella, many of its superficial fibres passing over the subcutaneous surface of the bone into the ligamentum patellæ; (2) of two lateral portions thinner, but strong. The lateral portions are inserted into the patella along its upper border on either side of the central portion and also into its lateral borders, nearer the anterior than the posterior surface, as low down as the attachment of the ligamentum patellæ; passing thence along the sides of the ligamentum patellæ to the tibia, they are attached to the oblique lines which extend laterally from the tubercle to the inner and outer tuberosities, and reach as far as the internal and external lateral ligaments. On the outer side, the fibres blend with the ilio-tibial band of the fascia lata, and on the inner they extend below the oblique line to blend with the periosteum of the shaft. Thus there is a large hood spread over the whole of the front of the joint, investing the patella, and reaching from the sides of the ligamentum patellæ to the lateral ligaments, attached below to the tibia, and separated everywhere from the synovial membrane by a layer of fatty tissue.

The **ligamentum patellæ** (fig. 247) is the continuation in line of the central portion of the conjoined tendon, some fibres of which are prolonged over the front of the patella into the ligament. It is an extremely strong, flat band, attached above to the lower border of the patella; below, it is fixed to the lower part of the tubercle and upper part of the crest of the tibia, somewhat obliquely, being prolonged downwards further on the outer side, so that this border is fully an inch longer than the inner which measures two inches and a half (6·7 cm.) in length. Behind, it is in contact with a mass of fat which separates it from the synovial membrane, and a small bursa intervenes between it and the head of the tibia. In front, a large bursa separates it from the subcutaneous tissue, and laterally it is continuous with the fibrous expansion of the extensors.

The **internal lateral ligament** (fig. 245) is a strong, flat band, which extends from the depression on the tubercle on the inner side of the internal condyle of the femur, to the inner border and internal surface of the shaft of the tibia, an inch and a half (3·7 cm.) below the tuberosity. It is three inches and a half (8·7 cm.) long, well defined anteriorly, where it blends with the expansion of the conjoined extensor tendons; but not so well defined posteriorly, where it merges into the posterior ligament. Some of the lower fibres blend with the descending portion of the *semimembranosus* tendon. Its deep surface is firmly adherent to the edge of the internal semilunar cartilage and coronary ligament, while part of the *semimembranosus tendon* and *inferior internal articular vessels* and *nerve* pass between it and the bone. Superficially, a bursa separates it from the tendons of the *gracilis* and *semitendinosus* muscles and from the aponeurosis of the *sartorius* muscle.

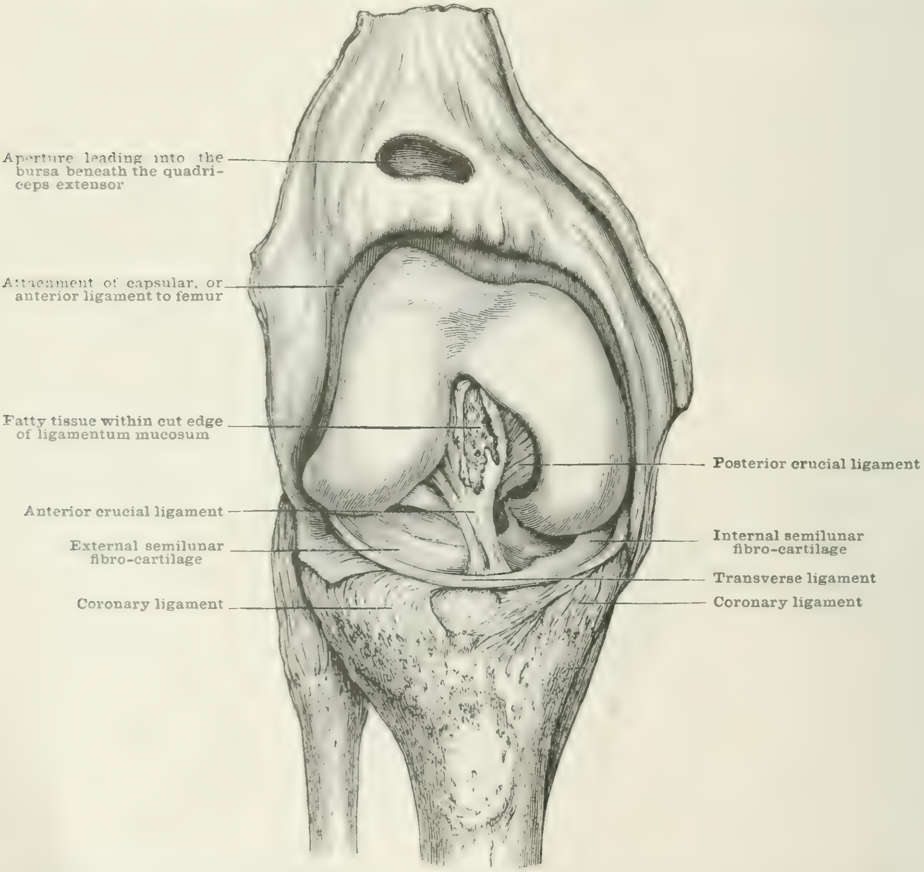
The **external lateral ligament** (fig. 245) consists of two portions: the **anterior,** which is the longer and better marked, is a strong, rounded cord, about two inches (5 cm.) long, attached above to the tubercle on the outer side of the external condyle of the femur, just below and in front of the origin of the outer head of the *gastrocnemius*, whilst the *tendon* of the *popliteus* arises from the groove below and in front of it. Below, it is fixed to the middle of the outer surface of the head of the fibula, half an inch (1·25 cm.) or more anterior to the styloid process. Superficially is the tendon of the *biceps*, which splits to embrace its lower extremity; while beneath it pass the *popliteus tendon* in its sheath, and the *inferior external articular vessels* and *nerve*. Some fibres of the peroneus longus occasionally arise from the lower end of the ligament. The **posterior** portion is a third of an inch (8 mm.) behind the anterior. It is broader and less defined; fixed below to the styloid process, it inclines upwards and somewhat backwards, and ties down the *popliteus* against the outer tuberosity, blending beneath the outer head of the *gastrocnemius* with the posterior ligament of the knee, of which it is really a portion.

FIG. 245.—POSTERIOR VIEW OF THE KNEE-JOINT.


Tendon of adductor magnus
Plantaris
Inner head of gastrocnemius
Outer head of gastrocnemius
External lateral ligament: anterior portion
Tendon of semi-membranosus with its slip to thicken the posterior ligament
Posterior part of external lateral ligament
Tendon of popliteus
Tendon of biceps
Internal lateral ligament
Posterior superior tibio-fibular ligament

The **posterior ligament** or **ligamentum Winslowii** (fig. 245) is a broad dense structure of interlacing fibres, with large orifices for vessels and nerves. It is attached above to the femur close to the articular margins of the condyles, stretching across the upper margin of the intercondyloid notch, to which it is connected by fibro-fatty tissue; it thus reaches across from the internal to the external lateral ligaments. Below, it is fixed to the border of the outer tuberosity of the tibia, to the bone just below the popliteal notch, and to the shaft of the tibia below the inner tuberosity, blending with the descending slip of the *semimembranosus* and internal lateral ligament. Superficially, an oblique fasciculus from the *semimembranosus* runs across the centre, passing upwards and outwards from near the back part of the inner tuberosity of the tibia to the external condyle of the femur where it joins the outer head of the gastrocnemius, a sesamoid plate being sometimes developed at the point of junction. This slip greatly strengthens the posterior ligament, of which, if not the chief constituent, it is at least a very important part.

Fig. 246.—Anterior View of the Internal Ligaments of the Knee-joint.


Aperture leading into the bursa beneath the quadriceps extensor
Attachment of capsular, or anterior ligament to femur
Fatty tissue within cut edge of ligamentum mucosum
Anterior crucial ligament
External semilunar fibro-cartilage
Coronary ligament
Posterior crucial ligament
Internal semilunar fibro-cartilage
Transverse ligament
Coronary ligament

Its deep surface is closely connected with the semilunar cartilages (especially the inner) and coronary ligaments, and in the interval between the cartilages with the posterior crucial ligament and fibro-fatty tissue within the joint. Superficially it forms part of the floor of the popliteal space.

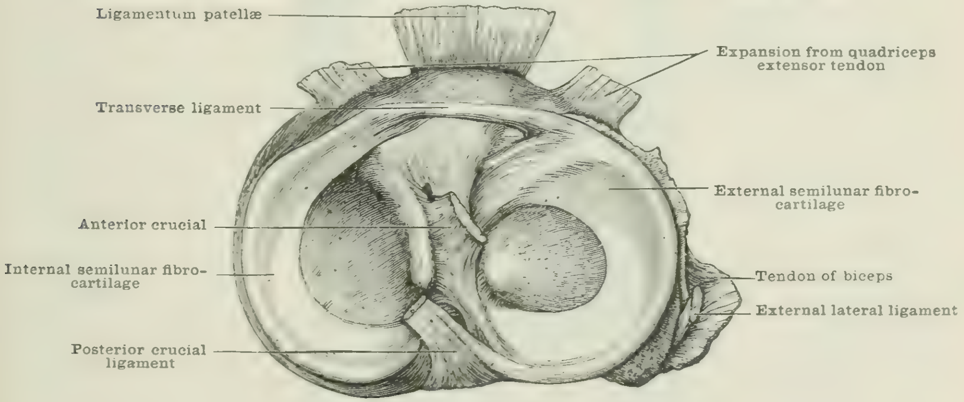
The **capsular** or **anterior ligament** (fig. 246) is thin but strong, covering the synovial membrane under the quadriceps extensor tendon, and looking like a loose sac. It is attached to the femur near the articular margin on the inner side, but further away on the outer; it passes beneath the external lateral ligament to join the sheath of the *popliteus*. Internally it joins the internal lateral ligament. Below, it is fixed to the upper and lateral borders of the patella and the anterior border of the head of the tibia. It is strengthened superficially between the femur and patella by an expansion from the *subcrureus*, and is separated from the fibrous expansion of the extensor tendon by a layer of fatty tissue. The synovial membrane lines its deep surface, and holds it against the borders of the semilunar cartilages; it is also attached to the coronary ligaments.

INTERNAL LIGAMENTS

The **anterior crucial ligament** (figs. 246 and 247) is strong and cord-like. It is attached to the inner half of the fossa in front of the spine of the tibia, and to the outer border of the inner articular facet as far back as the inner tubercle of the spine. It passes upwards, backwards, and outwards to the back part of the internal surface of the external condyle. To the tibia, it is fixed behind the anterior extremity of the internal semilunar cartilage. Behind and to the outer side it has the anterior extremity of the external semilunar cartilage, a few fibres of which blend with the outer edge of the ligament. Its anterior fibres at the tibial end are strongest and longest, being fixed highest on the femur; while the posterior, springing from the spine, are shorter and more oblique. Near the spine, a slip is sometimes given off to the posterior crucial.

The **posterior crucial ligament** (figs. 246, 247, and 248) is stronger and less oblique than the anterior. It is fixed below to the greater portion of the fossa behind the spine of the tibia, especially the outer and posterior portion, and then inwards and upwards along the popliteal notch; being joined by fibres which arise between the tubercles of the spine, it ascends to the anterior part of the outer surface of the inner condyle, having a wide crescentic attachment more than half an inch (1·5 cm.) in extent just above the articular surface. Behind, it is connected at the tibia directly with the posterior ligament, and a little higher up by means of a quantity of interposed areolar tissue. In front it rests upon the posterior horn of the internal semilunar cartilage, and receives a large slip from the external cartilage, which ascends along it either in front, or behind to the femur; higher up in front it is connected with the anterior crucial ligament.

Fig. 247.—Structures lying on the Head of the Tibia. (Right knee.)

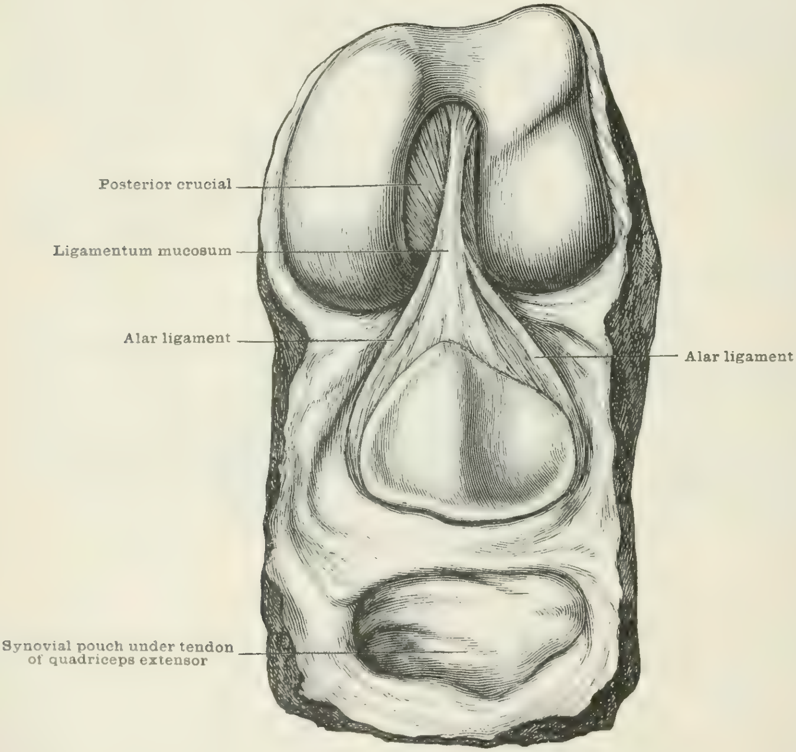

Ligamentum patellæ
Expansion from quadriceps extensor tendon
Transverse ligament
External semilunar fibro-cartilage
Anterior crucial
Internal semilunar fibro-cartilage
Tendon of biceps
External lateral ligament
Posterior crucial ligament

Until they rise above the spine of the tibia the two crucial ligaments are closely bound together, so that no interspace exists between their tibial attachments and the point of decussation; the only space between them is therefore a V-shaped one corresponding to the upper half of their X-shaped arrangement, and this is a mere chink in the undissected state, and can be seen from the front only, owing to the fatty tissue beneath the synovial membrane which surrounds their femoral attachment.

The **interarticular** or **semilunar fibro-cartilages** (figs. 246 and 247) are two crescentic plates resting upon the circumferential portions of the articular facets of the tibia, and moving with the tibia upon the femur. They somewhat deepen the tibial articular surfaces, and are dense and compact in structure, becoming looser and more fibrous near their extremities, where they are firmly fixed in front of and behind the spine of the tibia. The circumferential border of each is convex, thick, and somewhat loosely attached to the borders of the tuberosities of the tibia by the coronary ligaments, and the reflexion of the synovial membrane. The inner border is concave, thin, and free. Half an inch (1·3 cm.) broad at the widest part, they taper somewhat towards their extremities, and cover rather less than two-thirds of the articular facets of the tibia. Their upper surfaces are slightly concave, and fit on to the femoral condyles, while the lower are flat and rest on the head of the tibia; both surfaces are smooth and covered by synovial membrane.

The **external semilunar cartilage** (fig. 247) is nearly circular in form and less firmly fixed than the internal, and consequently slides more freely upon the tibia.

FIG. 248.—ANTERIOR VIEW OF THE KNEE-JOINT, SHOWING THE SYNOVIAL LIGAMENTS. (Anterior portion of capsule with the extensor tendon thrown downwards.)



Its anterior cornu is attached to a narrow depression along the outer articular facet, just in front of the external tubercle of the tibial spine, close to, and on the outer side of, the anterior crucial ligament; a small slip from the cornu is often fixed to the tibia in front of the crucial ligament. The posterior cornu is firmly attached to the tibia behind the external tubercle of the spine, blending with the posterior crucial ligament, and giving off a well-marked fasciculus, which runs up along the anterior border of the ligament to be attached to the femur (ligament of Wrisberg). It also sends a narrow slip into the back part of the anterior crucial ligament.

Its outer border is grooved towards its posterior part by the *popliteus* tendon, which is held to it by fibrous tissue and synovial membrane, and separates it from the external lateral ligament. From its anterior border is given off the transverse ligament.

The **internal semilunar cartilage** (fig. 247) is a segment of a larger circle than the external, and has an outline more oval than circular. Its anterior cornu is wide, and has a broad and oblique attachment to the anterior margin of the head of the tibia. It reaches backwards and outwards from the margin of the tuberosity towards the middle of the fossa in front of the tibial spine, being altogether in front of the anterior crucial ligament. The posterior cornu is firmly fixed by a broad insertion in an antero-posterior line along the inner side of the posterior fossa, from the internal tubercle of the spine to the posterior margin of the head of the tibia. Its convex border is connected with the internal lateral ligament and the *semimembranosus* tendon.

The **transverse ligament** (figs. 246 and 247) is a rounded, slender, short cord, which extends from the convex border of the external semilunar cartilage to the concave border or anterior cornu of the internal, near which it is sometimes attached to the bone. It is an accessory band of the external cartilage, and is situated beneath the synovial membrane.

The **coronary ligaments** (fig. 246) connect the margins of the semilunar fibro-cartilages with the head of the tibia. The external is much more lax than the internal, permitting the outer cartilage to change its position more freely than the inner. They are not in reality separate structures, but consist of fibres of the several surrounding ligaments of the knee-joint which become attached to, as they pass over the margins of the fibro-cartilages.

The **synovial membrane** (fig. 249) of the knee forms the largest synovial sac in the body. Bulging upwards from the patella, it follows the capsule of the joint into a large *cul-de-sac* beneath the tendon of the extensor muscles on the front of the femur. It reaches some distance beyond the articular surface of the bone, and communicates very frequently with a large bursa interposed between the tendon and the femur above the line of attachment of the capsular ligament. After investing the circumference of the lower end of the femur, it is reflected upon the fibrous envelope of the joint formed by the capsular, posterior, and lateral ligaments. It covers a great portion of the crucial ligaments, but leaves uncovered the back of the posterior crucial where the latter is connected with the posterior ligament, and the lower part of both crucial ligaments where they are united. Thus the ligaments are completely shut out of the synovial cavity. Along the fibrous envelope the synovial membrane is conducted down to the semilunar cartilages, over both surfaces of which it passes, and is reflected off the under surface on to the coronary ligaments, and thence down to the head of the tibia, around the circumference of which it extends a short way. It dips down between the external cartilage and the head of the tibia as low as the superior tibio-fibular ligament, reaching inwards nearly as far as the popliteal notch, and forming a bursa for the play of the popliteal tendon.

At the back of the joint two pouches are prolonged beneath the muscles, one on each side between the condyle of the femur and the origin of the gastrocnemius.

Large processes of synovial membrane also project into the joint, and being occupied by fat serve as padding to fill up spaces. The chief of these processes, the **ligamentum mucosum** (figs. 248 and 249) springs from the infrapatellar fatty mass. This so-called ligament is the central portion of the large process of synovial membrane, of which the alar ligaments form the lateral free margins. It extends from the fatty mass, below the patella, backwards and upwards to the intercondyloid notch of the femur, where it is attached in front of the anterior crucial, and to the outer side of the posterior crucial ligament. Near the femur it is thin and transparent, consisting of a double fold of synovial membrane, but near the patella it contains some fatty tissue. Its anterior or upper edge is free, and fully an inch (2·5 cm.) long; the posterior or lower edge is half the length, and is attached to the crucial ligaments above, but is free below.

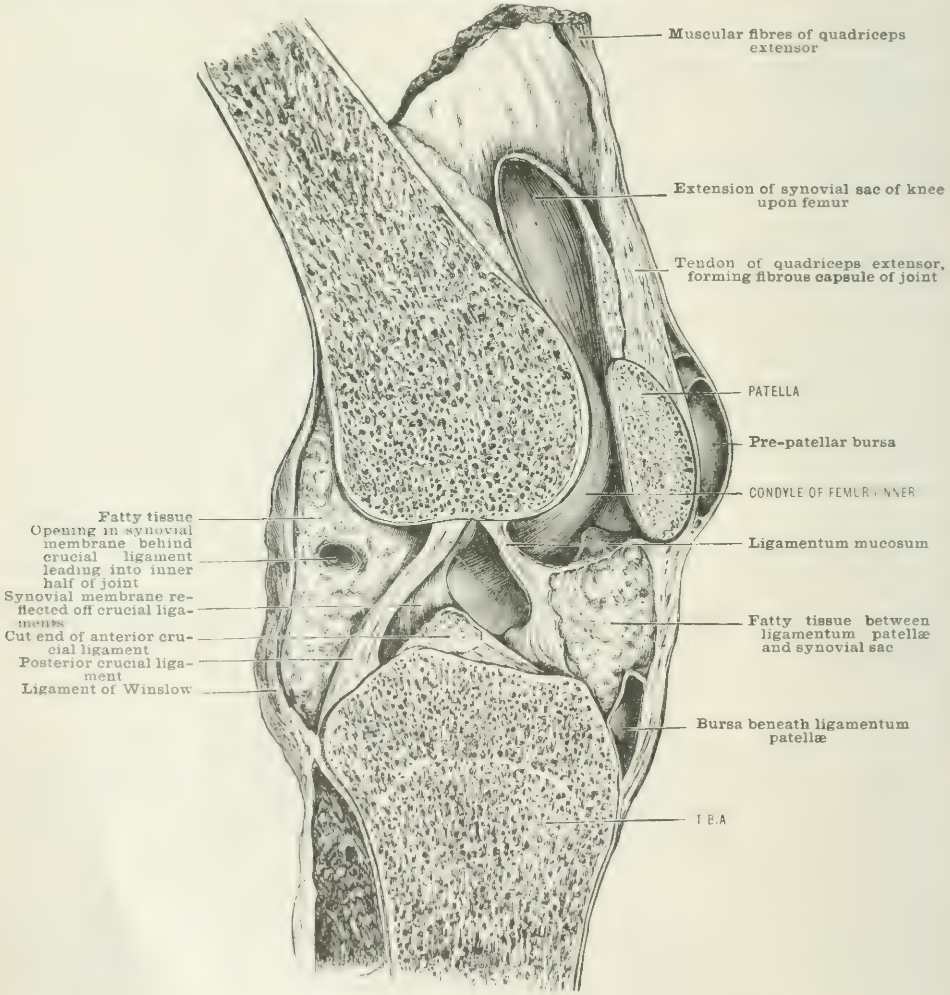
Passing backwards from the capsule on each side of the patella is a prominent crescentic fold formed by reduplications of the synovial membrane—these are the **alar ligaments** (fig. 248). Their free margins are concave and thin, and are lost below in the ligamentum mucosum. There is a slight fossa above and another below each ligament.

The **arterial supply** is derived from the anastomotica femoris; the superior and inferior internal and external articular; the azygos articular; the descending branch of the external circumflex; the anterior recurrent branch from the anterior tibial; and the posterior tibial recurrent.

The **nerve-supply** comes from the great sciatic, anterior crural, and obturator sources. The **great sciatic** gives off the internal and external popliteal; the internal popliteal sends two, sometimes three branches—one with the azygos artery; one with the inferior internal, and sometimes one with the superior internal articular artery; the external popliteal gives a branch which accompanies the superior, and another which accompanies the inferior articular artery, and a recurrent branch which follows the course of the anterior recurrent branch of the anterior tibial artery. The **anterior crural** sends an articular branch from the nerve to the vastus externus; a second from the nerve to the vastus internus; and sometimes a third from that to the crureus. Thus there are three articular twigs to the knee derived from the muscular branches of the anterior crural. (Roger Williams, Journ. Anat. Physiol., 1879.) The **obturator** by its deep division sends a branch through the adductor magnus on to the popliteal artery, which enters the joint through the posterior ligament.

FIG. 249.—VERTICAL SECTION OF THE KNEE-JOINT IN THE ANTERO-POSTERIOR DIRECTION.

(The bones are somewhat drawn apart.)

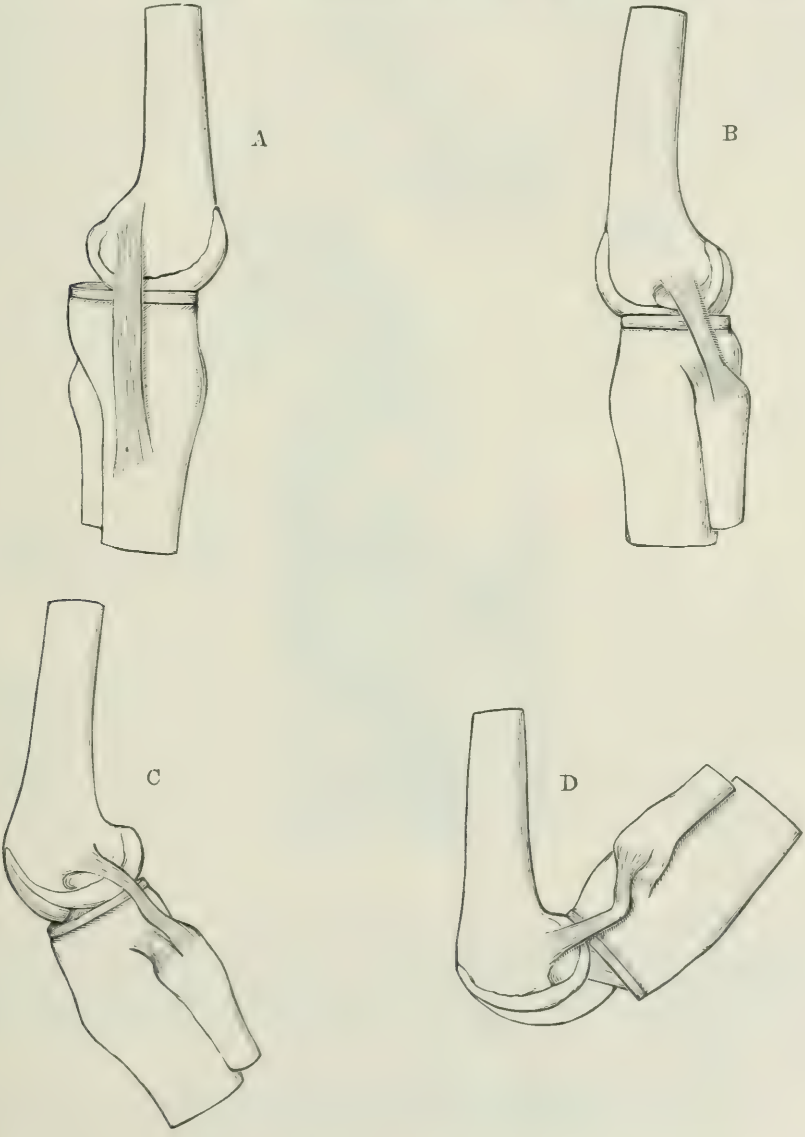

Muscular fibres of quadriceps extensor
Extension of synovial sac of knee upon femur
Tendon of quadriceps extensor, forming fibrous capsule of joint
PATELLA
Pre-patellar bursa
CONDYLE OF FEMUR (INNER)
Ligamentum mucosum
Fatty tissue between ligamentum patellæ and synovial sac
Bursa beneath ligamentum patellæ
T.B.A
Fatty tissue
Opening in synovial membrane behind crucial ligament leading into inner half of joint
Synovial membrane reflected off crucial ligaments
Cut end of anterior crucial ligament
Posterior crucial ligament
Ligament of Winslow

The **movements** which occur at the knee-joint are flexion and extension, with some slight amount of rotation in the bent position. These movements are not so simple as the corresponding ones at the elbow, for the knee is not a simple hinge joint. The rotation inwards and outwards are movements of the tibia with the fibula upon the condyles of the femur.

The knee differs from a true hinge joint like the elbow or ankle, in the following particulars:—

1. The points of contact of the femur with the tibia are constantly changing. Thus, in the flexed position, the hinder part of the articular surface of the tibia is in contact with the rounded back part of the condyles; in the semiflexed position the middle parts of the tibial facets articulate with the anterior rounded part of the condyles; while in the fully extended position the anterior and middle parts of the tibial facets are in contact with the anterior flattened portion of the condyles. So with the patella: in extreme flexion the inner articular facet rests on the outer part

Fig. 250.—The Lateral Ligaments of the Knee in Flexion and Extension.



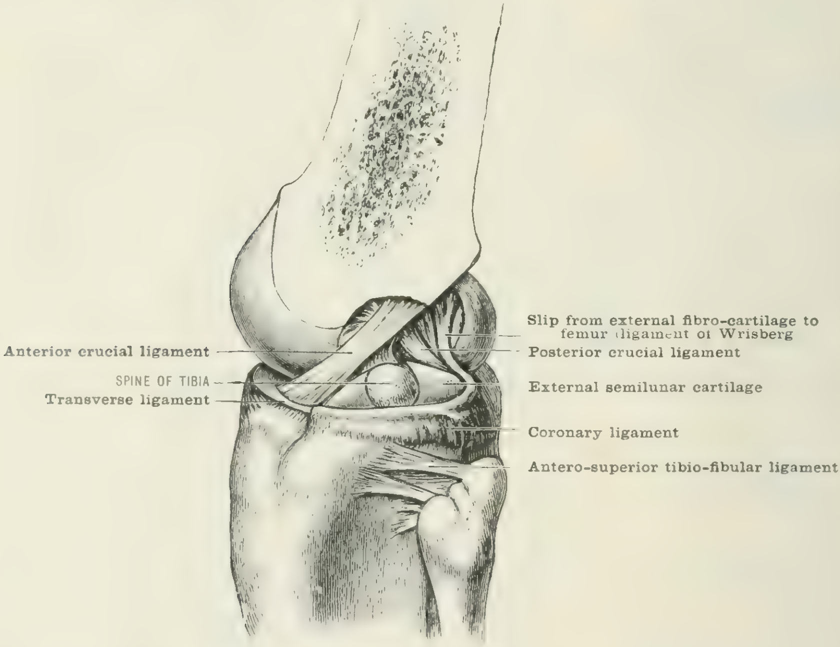
of the internal condyle of the femur; in flexion the upper pair of facets rest on the lower part of the trochlear surface of the femur; in mid-flexion the middle pair rest on the middle of the trochlear surface; while in extension the lower pair of facets on the patella rest on the upper portion of the trochlear surface of the femur.

This difference may be described as the shifting of the points of contact of the articular surface.

2. It differs from a true hinge in that, in passing from a state of extension to one of flexion, the tibia does not revolve round a single transverse axis drawn through the lower end of the femur, as the ulna does round the lower end of the humerus. The articular surface of the tibia slides forwards in extension and backwards in flexion; thus the axis round which the tibia revolves upon the femur is a shifting one, as is seen by reference to fig. 250, B, C, D.

3. Another point of difference is that extension is accompanied by rotation outwards, and flexion by rotation inwards. This rotation occurs round a vertical axis drawn through the middle of the outer condyle of the femur and the outer tuberosity of the tibia, and is most marked at the termination of extension and at the commencement of flexion. This rotation of the leg at the knee is a true rotation about a vertical axis, and thus differs from the obliquity of the flexion and extension movements at the elbow which is due to the oblique direction of the articular surfaces of the bones.

Fig. 251.—Section of Knee, showing Crucials in Extension.

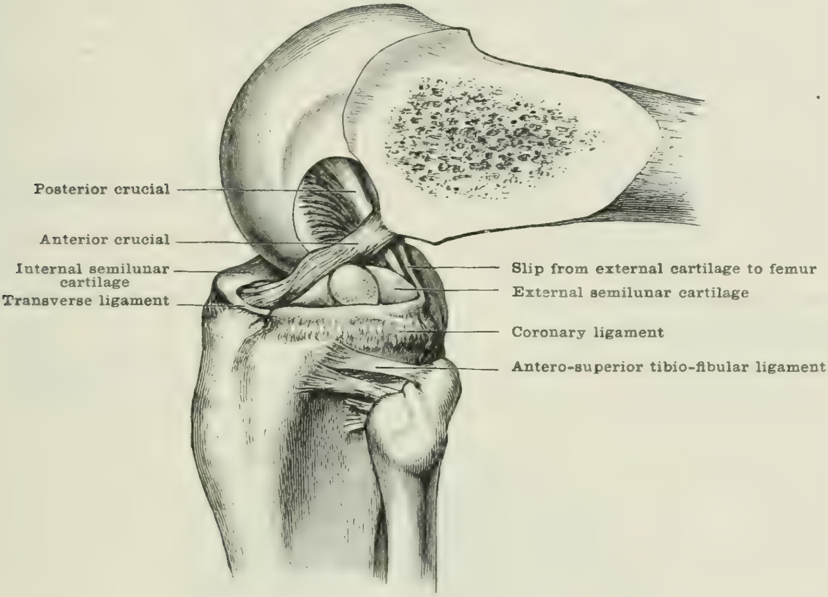

Anterior crucial ligament
SPINE OF TIBIA
Transverse ligament
Slip from external fibro-cartilage to femur (ligament of Wrisberg
Posterior crucial ligament
External semilunar cartilage
Coronary ligament
Antero-superior tibio-fibular ligament

4. The **antero-posterior spiral curve** of the femoral condyles is such, that the anterior part is an arc of a greater circle than the posterior; hence certain ligaments which are tightened during extension are relaxed during flexion, and thereby a considerable amount of rotatory movement is permitted in the flexed position. The axis of this rotation is vertical, and passes through the inner tubercle of the spine of the tibia, so that the outer tuberosity moves in the arc of a larger circle than does the inner, and is therefore required to move more freely and easily; hence the shape of the external articular facet and the loose connection of the external semilunar cartilage which is adapted to it.

In **extension**, all the ligaments are on the stretch with the exception of the ligamentum patellæ and front of the capsule. Extension is checked by both the crucial ligaments and the lateral ligaments (figs. 250, A, B, and 251).

In **flexion** the ligamentum patellæ and anterior portion of the capsule are on the stretch; so also is the posterior crucial in extreme flexion, though it is not quite tight in the semiflexed state of the joint. All the other ligaments are relaxed (fig. 250, C, D), although the relaxation of the anterior crucial ligament is slight in extreme flexion (fig. 252). Flexion is only checked during life by the contact of the soft parts, i.e. the calf with the back of the thigh.

FIG. 252.—CRUCIAL LIGAMENTS IN FLEXION.


Posterior crucial
Anterior crucial
Internal semilunar cartilage
Transverse ligament
Slip from external cartilage to femur
External semilunar cartilage
Coronary ligament
Antero-superior tibio-fibular ligament

Inward rotation is checked by the anterior crucial ligament; the lateral ligaments being loose.

Outward rotation is checked by the lateral ligaments; the crucial ligaments have no controlling effect on it, as they are untwisted by it.

Sliding movements are checked by the crucials and lateral ligaments—sliding forwards especially by the anterior, and sliding backwards by the posterior crucial.

3. THE TIBIO-FIBULAR UNION

The fibula is connected with the tibia throughout its length by an interosseous membrane, and at the upper and lower extremities by means of two joints. Very little movement is permitted between the two bones.

(*a*) The **superior tibio-fibular joint.**
(*b*) The **middle tibio-fibular union.**
(*c*) The **inferior tibio-fibular joint.**

(*a*) THE SUPERIOR TIBIO-FIBULAR JOINT

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The superior tibio-fibular joint is about a quarter of an inch (6 mm.) below, and quite distinct from, the knee at its upper and anterior part; but at its posterior and superior aspect, where the border of the outer tuberosity of the tibia is bevelled by the popliteus muscle, the joint is in the closest proximity to the bursa beneath the tendon of that muscle, and is only separated from the knee-joint by a thin septum of areolar tissue. There is often a communication between the synovial cavities of the two joints. The ligaments uniting the bones are:—

Capsular. Anterior tibio-fibular.
Posterior tibio-fibular.

The **capsular ligament** is a well-marked fibro-areolar structure; it is attached close round the articular margins of the tibia and fibula. In front it is shut off completely from the knee-joint by the capsule of the knee and the coronary ligament; but behind, it is often very thin, and may communicate with the bursa under the popliteus tendon.

The **anterior tibio-fibular ligament** (fig. 251) consists of a few fibres which pass upwards and inwards from the fibula to the tibia. It lies beneath the anterior portion of the tendon of the biceps.

The **posterior tibio-fibular ligament** (fig. 245) consists of a few fibres which pass upwards and inwards between the adjacent bones, from the head of the fibula to the outer tuberosity of the tibia.

The **superior interosseous ligament** consists of a mass of dense yellow fibro-areolar tissue, binding the opposed surfaces of the bones together for three-quarters of an inch (2 cm.) below the articular facets. It is continuous with the interosseous membrane along the tibia.

The **biceps tendon** is divided by the long external lateral ligament of the knee; of the two divisions the anterior is by far the stronger, and is attached to the external tuberosity of the tibia as well as to the front of the head of the fibula, and thus the muscle, acting on both bones, tends to brace them more tightly together; indeed, it holds the bones strongly together after all other connections have been severed.

The **synovial membrane** which lines the joint sometimes communicates with the knee-joint through the bursa beneath the popliteus tendon.

The **arterial supply** is from the inferior external articular and recurrent tibial arteries.

The **nerve-supply** is from the inferior external articular, and also from the recurrent branch of the external popliteal.

The **movements** are but slight, and consist merely of a gliding of the two bones upon each other. The joint is so constructed that the fibula gives some support to the tibia in transmitting the weight to the foot. The articular facet of the tibia overhangs, and is received upon the articular facet of the head of the fibula in an oblique plane. This joint allows of slight yielding of the external malleolus during flexion and extension of the ankle-joint, the whole fibula gliding slightly upwards in flexion, and downwards in extension of the ankle.

(*b*) The Middle Tibio-fibular Union

The **interosseous membrane** is attached along the outer border of the tibia and the interosseous border of the fibula. It is deficient above for about an inch (2·5 cm.) or more, measured from the under aspect of the superior joint. Its upper border is concave, and over it pass the anterior tibial vessels. The membrane consists of a thin aponeurotic and translucent lamina, formed of oblique fine fibres, some of which run from the tibia to the fibula, and some from the fibula to the tibia, but all are inclined downwards. They are best marked at their attachment to the bones, and gradually grow denser and thicker as they approach the inferior interosseous ligament. The chief use of the membrane is to afford a surface for the origin of muscles. It is continuous below with the inferior interosseous ligament.

(c) The Inferior Tibio-fibular Articulation

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

This junction is formed by the lower ends of the tibia and fibula. The rough triangular surface on each of these bones formed by the bifurcation of their interosseous lines is closely and firmly united by the inferior interosseous ligament. The fibula is in actual contact with the tibia by an articular facet, which is small in size, crescentic in shape, and continuous with the articular facet of the malleolus.

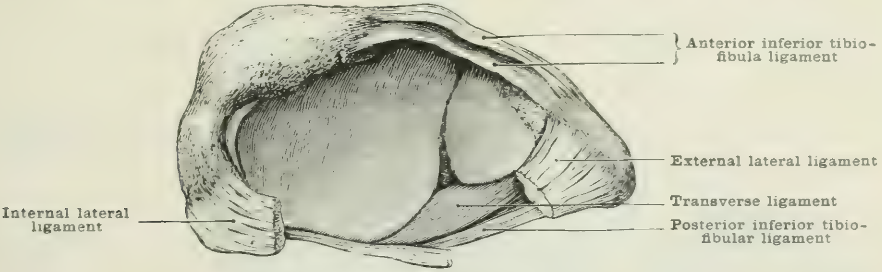
The ligaments which unite the bones are:—

1. Anterior inferior tibio-fibular ligament.
2. Posterior inferior tibio-fibular ligament.
3. Transverse ligament.
4. Inferior interosseous ligament.

The **antero-inferior tibio-fibular ligament** (figs. 252 A and 255) is a strong triangular band about three-quarters of an inch (2 cm.) wide, and is attached to the lower extremity of the tibia at its anterior and external angle, close to the margin of the facet for the astragalus, and passes downwards and outwards to the anterior border and contiguous surface of the lower end of the fibula, some fibres passing along the edge nearly as far as the origin of the anterior fasciculus of the external lateral ligament. The fibres increase in length from above downwards. In front it is in relation with the *peroneus tertius* and deep fascia of the leg, and gives origin to fibres of the anterior ligament of the ankle-joint. Behind, it lies in contact with the interosseous ligament, and comes into contact with the articular surface of the astragalus (see figs. 252 A and 252 B).

Fig. 252 A.—Lower Ends of Left Tibia and Fibula, showing the Ligaments. The synovial fold between these bones has been removed to show the transverse ligament forming part of the capsule of the joint, and the deeper fibres of the anterior inferior tibio-fibular ligament which come into contact with the astragalus.

(From a dissection by Mr. W. Pearson, of the Royal College of Surgeons' Museum.)


Anterior inferior tibio-fibula ligament
External lateral ligament
Transverse ligament
Posterior inferior tibio-fibular ligament
Internal lateral ligament

The **postero-inferior tibio-fibular ligament** (figs. 254 and 255) is very similar to the anterior, extending from the posterior and external angle of the lower end of the tibia downwards and outwards to the lowest half-inch (1·5 cm.) of the border separating the internal from the posterior surface of the shaft of the fibula, and to the upper part of the posterior border of the external malleolus. It is in relation in front with the interosseous ligament; below, it touches the transverse ligament.

The **inferior interosseous ligament** is a dense mass of short felt-like fibres, passing transversely between and firmly uniting the opposed rough triangular surfaces at the lower ends of the tibia and fibula, except for three-eighths of an inch (1 cm.) at the extremity, where there is a synovial cavity. It extends from the anterior to the posterior tibio-fibular ligaments, reaching upwards an inch and a half in front (4 cm.), but only half this height behind.

The **transverse ligament** (fig. 254) is a strong rounded band, attached to nearly the whole length of the inferior border of the posterior surface of the tibia, just above the articular facet for the astragalus. It then inclines a little forwards and downwards, to be attached to the internal surface of the external malleolus, just above the fossa, and the upper part of the fossa itself.

The **synovial membrane** is continuous with that of the ankle-joint; it projects upwards between the bones beyond their articular facets as high as the inferior interosseous ligament.

The **nerve-supply** is the same as that of the ankle-joint; the **arterial** supply is from the peroneal and the anterior peroneal, and sometimes from the anterior tibial, or its external malleolar branch.

The **movement** permitted at this joint is a mere gliding, chiefly in an upward and downward direction, of the fibula on the tibia. The bones are firmly braced together and yet form a slightly yielding arch, thus allowing a slight lateral expansion during extreme flexion, when the broad part of the astragalus is brought under the arch, by the upward gliding of the fibula on the tibia. To this end the direction of the fibres of the superior and inferior tibio-fibular ligaments is downwards from tibia to fibula. This mechanical arrangement secures perfect contact of the articular surfaces of the ankle-joint in all positions of the foot.

4. THE ANKLE-JOINT

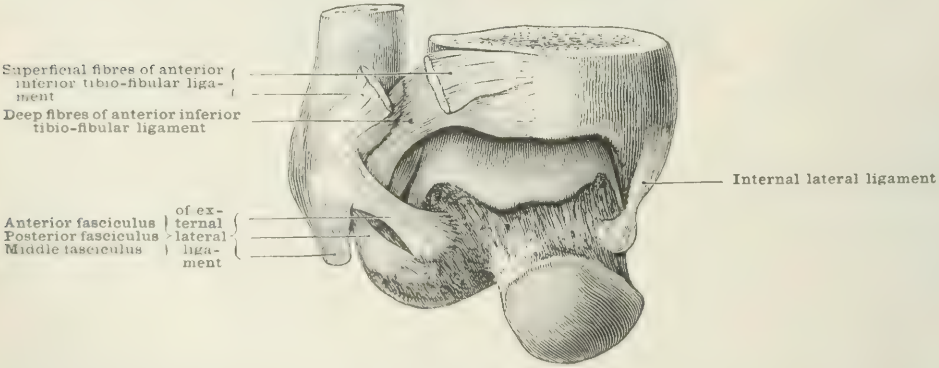
Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

The ankle is a perfect ginglymus or hinge joint. The bones which enter into its formation are: the lower extremity and internal malleolus of the tibia, and the external malleolus of the fibula, above; and the upper and lateral articular surfaces of the astragalus below. The ligaments uniting the bones are:—

Anterior.	Internal lateral.
Posterior.	External lateral.

Fig. 252 B.—Right Ankle-joint, showing the Ligaments.

(From dissection by Mr. W. Pearson, of the Royal College of Surgeons' Museum.)

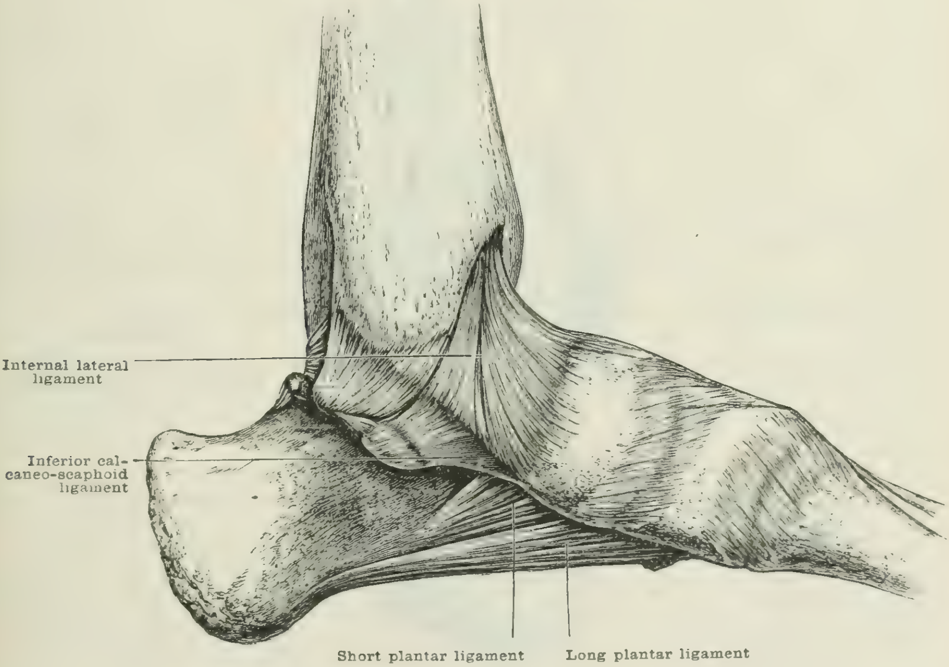

Superficial fibres of anterior inferior tibio-fibular ligament
Deep fibres of anterior inferior tibio-fibular ligament
Internal lateral ligament
Anterior fasciculus
Posterior fasciculus
Middle fasciculus
of external lateral ligament

The **anterior ligament** (fig. 255) is a thin, membranous structure, which extends between the lateral ligaments. It is attached above to the anterior border of the internal malleolus, to a crest of bone just above the transverse groove at the lower end of the tibia, to the anterior inferior tibio-fibular ligament, and to the anterior border of the external malleolus. Below, it is attached to the rough upper surface of the neck of the astragalus, in front of the fossa. Internally it is thicker, and is fixed to the astragalus close to the facet for the inner malleolus, being continuous with the internal lateral ligament, and passing forwards to blend with the dorsal astragalo-scaphoid ligament. Externally it is attached to the astragalus, just below and in front of the angle between the superior and lateral facets, close to their edges, and joins the anterior fasciculus of the external lateral ligament. It is in relation, in front with the *tibialis anticus* muscle, the anterior tibial vessels and nerve, the *extensor tendons of the toes*, and the *peroneus tertius*; and behind with a mass of fat and synovial membrane.

The **posterior ligament** (fig. 254) is a very thin and disconnected membranous structure, connected above with the external malleolus, internal to the peroneal groove; to the posterior margin of the lower end of the tibia external to the groove for the tibialis posticus; and to the posterior inferior tibio-fibular ligament. Below, it is attached to the posterior surface of the astragalus from the internal to the external lateral ligaments. The passage of the flexor longus hallucis tendon over the back of the joint serves the purpose of a much stronger posterior ligament.

The **internal lateral** or **deltoid ligament** (fig. 253) is attached superiorly to the internal malleolus along its lower border, and to its anterior surface superficial to the anterior ligament; some very strong fibres are fixed to the notch in the lower border of the malleolus, and, getting attachment below to the rough depression on the inner side of the astragalus, form a **deep** portion to the ligament. The ligament radiates; the posterior fibres are short, and incline a little backwards to be fixed to the rough inner surface of the astragalus, close to the superior articular facet, and into the tubercle to the inner side of the flexor longus hallucis groove. The fibres next in front are numerous and form a thick and strong mass, filling up the rough depression on the inner surface of the astragalus, whilst some pass over the calcaneo-astragaloid joint to the upper and inner border of the sustentaculum tali. The fibres, which are connected above with the anterior surface of the malleolus, pass downwards and somewhat forwards to be attached to the scaphoid and to the margin of the calcaneo-scaphoid ligament.

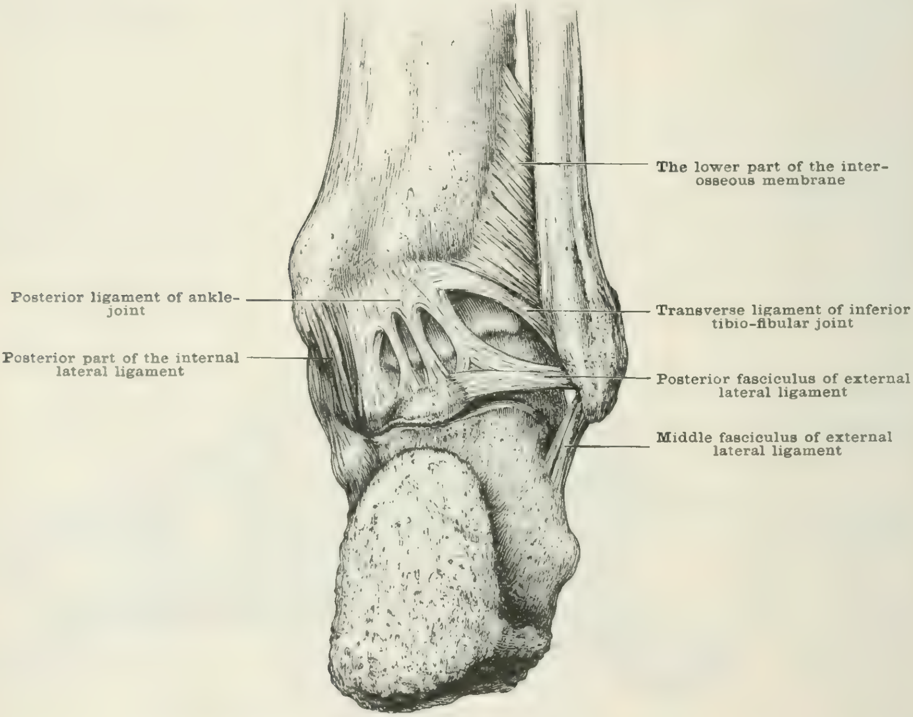
FIG. 253.—INNER VIEW OF THE ANKLE AND THE TARSUS, SHOWING THE GROOVE FOR THE TENDON OF THE TIBIALIS POSTICUS.


Internal lateral ligament
Inferior calcaneo-scaphoid ligament
Short plantar ligament
Long plantar ligament

The **external lateral ligament** (figs. 254 and 255) consists of three distinct slips. The **anterior fasciculus** is ribbon-like and passes from the anterior border of the external malleolus near the tip to the rough surface of the astragalus in front of the external lateral facet, and overhanging the sinus pedis. The **middle fasciculus** is a strong roundish bundle, which extends downwards and somewhat backwards from the anterior border of the external malleolus close to the attachment of the anterior fasciculus, and from the outer surface of the malleolus, just in front of the apex, to a tubercle on the middle of the outer surface of the calcaneum. The **posterior fasciculus** is almost horizontal; it is a strong, thick band attached at one end to the posterior border of the malleolus, and slightly to the fossa on the internal surface; and at the other end to the astragalus, behind the articular facet for the tibula, as well as to a tubercle on the outer side of the groove for the *flexor longus hallucis*. The middle fasciculus is covered by the tendons of the *peronei longus* and *brevis;* and in extension, the posterior fasciculus is received into the pit on the inner surface of the external malleolus.

The **synovial membrane** is very extensive. Besides lining the ligaments of the ankle, it extends upwards between the tibia and fibula, forming a short *cul-de-sac* as far as the interosseous ligament. Upon the anterior and posterior ligaments it is very loose, and extends beyond the limits of the articulation. It is said to contain more synovia than any other joint.

FIG. 254.—LIGAMENTS SEEN FROM THE BACK OF THE ANKLE-JOINT.


The lower part of the interosseous membrane
Posterior ligament of ankle-joint
Transverse ligament of inferior tibio-fibular joint
Posterior part of the internal lateral ligament
Posterior fasciculus of external lateral ligament
Middle fasciculus of external lateral ligament

The **nerve-supply** is from the internal saphenous, posterior tibial, and the external division of the anterior tibial.

The **arterial supply** comes from the anterior tibial, the anterior peroneal, the external malleolar, the posterior tibial, and posterior peroneal.

Movements.—This being a true hinge joint, flexion and extension are the only movements of which it is capable, there being no lateral motion, except in extreme extension, when the narrowest part of the astragalus is thrust forwards into the widest part of the tibio-fibular arch. In flexion the astragalus is tightly embraced by the malleoli, and lateral movement is impossible. Flexion is limited by: (i) nearly the whole of the fibres of the internal lateral ligament, none but the most anterior being relaxed; (ii) the posterior and middle portions of the external lateral ligament, especially the posterior; (iii) the posterior ligament of the ankle. It is also limited by the neck of the astragalus abutting on the edge of the tibia. Extension is limited by: (i) the anterior fibres of the internal lateral ligament; (ii) the anterior and middle portions of the external lateral ligament; (iii) the inner and stronger fibres of the anterior ligament. It is also limited by the posterior portion of the astragalus meeting with the tibia. Thus the middle portion of the external lateral ligament is always on the stretch, owing to its obliquely backward direction, whereby it limits flexion; and its attachment to the fibula in front of the malleolar apex, whereby it prevents over-extension as soon as the foot begins to twist inwards. This inward twisting, or adduction of the foot, is partly due to the greater posterior length of the inner border of the superior articular surface of the astragalus, and to the less proportionate height posteriorly of the external border of that surface, but chiefly to the lateral movement in the calcaneo-astragaloid joints. Flexion and extension take place round a transverse axis drawn through the body of the astragalus. The movement is not in a direct antero-posterior plane, but on a plane inclined forwards and outwards from the middle of the astragalus to the intermetatarsal joint of the second and third toes.

5. THE TARSAL JOINTS

These may again be divided up into the following sub-groups:—

(*a*) The **calcaneo-astragaloid union.**
(*b*) The **articulations of the anterior portion of the tarsus.**
(*c*) The **medio-tarsal joint.**

(*a*) The Calcaneo-astragaloid Union

There are two joints which enter into this union—viz. an anterior and a posterior.

(i) *The Posterior Calcaneo-astragaloid Joint*

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The calcaneum articulates with the astragalus by two joints, the anterior and posterior: the former communicates with the medio-tarsal: the posterior is separate and complete in itself. The two bones are united by the following ligaments:—

Interosseous.	External calcaneo-astragaloid.
Posterior calcaneo-astragaloid.	Internal calcaneo-astragaloid.

The **interosseous ligament** (figs. 255 and 256) is a strong band connecting the apposed surfaces of the calcaneum and astragalus along their oblique grooves. It is composed of several vertical laminæ of fibres, with some fatty tissue in between. It is better marked, deeper, and broader externally. Strong laminæ extend from the rough inferior and external surfaces of the neck of the astragalus to the rough superior surface of the os calcis anteriorly, forming the posterior boundary of the anterior calcaneo-astragaloid joint; these have been described as the **anterior interosseous ligament.** The posterior laminæ extend from the roof of the sinus pedis to the os calcis immediately in front of the external facet, thus forming the anterior part of the capsule of the posterior joint.

The **external calcaneo-astragaloid ligament** (fig. 255) extends from the groove just below and in front of the external articular facet of the astragalus, to the os calcis some little distance from the articular margin. Its fibres are nearly parallel with those of the middle fasciculus of the external lateral ligament of the ankle, which passes over it and adds to its strength. It fills up the interval between the middle and anterior fasciculus of the external lateral ligament, a considerable bundle of its fibres blending with the anterior border of the middle fasciculus.

The **posterior calcaneo-astragaloid ligament** passes from the external tubercle and lower edge of the groove for the flexor longus hallucis to the os calcis, a variable distance from the articular margin.

The **internal calcaneo-astragaloid ligament** is a narrow band of well-marked fibres passing obliquely downwards and backwards from the depression on the astragalus, just behind the inner end of the sinus pedis, to the os calcis behind the sustentaculum tali, thus completing the floor of the groove for the flexor longus hallucis tendon.

The **synovial sac** is distinct from any other.

The **nerve-supply** is from the posterior tibial or one of its plantar branches.

The **arteries** are, a branch from the posterior tibial, which enters at the inner end of the sinus pedis; and twigs from the tarsal, external malleolar, and the peroneal, which enter at the outer end of the sinus.

(ii) *The Anterior Calcaneo-astragaloid Joint*

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

This joint is formed by the anterior facet on the upper surface of the os calcis and the facets on the lower surface of the neck and head of the astragalus; it is bounded laterally and behind by ligaments, and communicates anteriorly with the astragalo-scaphoid joint. The ligaments are:—

Interosseous. Internal (or antero-internal) calcaneo-astragaloid.
External calcaneo-scaphoid.

The **interosseous ligament** by its anterior laminæ limits this joint posteriorly. It has been already described (p. 269).

The **antero-internal calcaneo-astragaloid** ligament consists of short fibres attached above to the rough depression on the internal surface of the neck of the astragalus, and below to the upper edge of the free border of the sustentaculum tali, blending posteriorly with the inner extremity of the interosseous ligament, and anteriorly with the upper border of the inferior calcaneo-scaphoid ligament. It is strengthened by the internal lateral ligament, the anterior fibres of which are also attached to the inferior calcaneo-scaphoid ligament.

The **external calcaneo-scaphoid** (superior calcaneo-scaphoid, Gray) (figs. 255 and 256) limits this, as well as the astragalo-scaphoid joint, on the outer side. It is a strong, well-marked band, extending from the rough upper surface of the calcaneum, external to the anterior facet, to a slight groove on the outer surface of the scaphoid near the posterior margin. It blends below with the inferior calcaneo-scaphoid, and above with the astragalo-scaphoid ligament. Its fibres run obliquely forwards and inwards. The internal lateral, and middle fasciculus of the external lateral ligaments of the ankle-joint also add to the security of these two joints, and assist in limiting movements between the bones by passing over the astragalus to the os calcis.

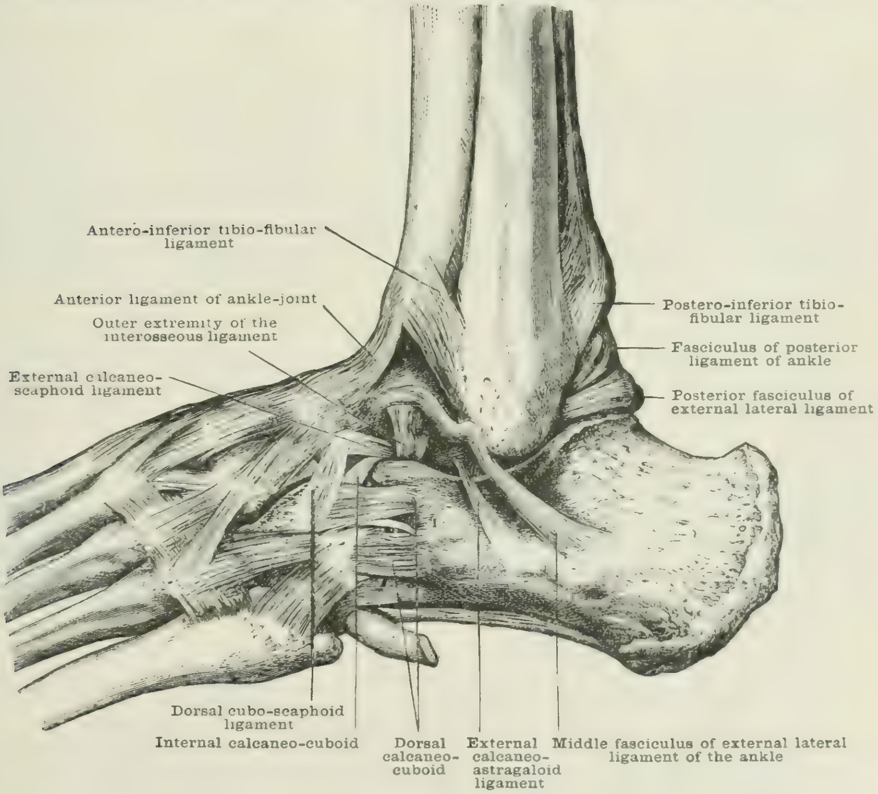
The **movements** of which these two joints are capable are adduction and abduction, with some amount of rotation. Adduction, or inclination of the sole inwards, being combined with some rotation of the toes inwards, and of the heel outwards; while abduction, or inclination of the foot outwards, is associated with turning of the toes outwards and the heel inwards. Thus the variety and the range of movements of the foot on the leg, which at the ankle are almost limited to flexion and extension, are increased. The cuboid moves with the calcaneum, while the scaphoid revolves on the head of the astragalus.

In walking, the heel is first placed on the ground; the foot is slightly adducted; but as the body swings forwards, first the outer then the inner toes touch the ground, the astragalus presses against the scaphoid and sinks upon the spring ligament; the foot then becomes slightly abducted. When the foot is firmly placed on the ground, the weight is transmitted to it obliquely downwards and inwards, so that if the ligaments between the calcaneum and astragalus did not check abduction, inward displacement of the astragalus from the tibio-fibular arch would only be prevented by the tendons passing round the inner ankle (especially the *tibialis posticus*). If the ligaments be too weak to limit abduction, the weight of the body increases it, and forces the inner malleolus and astragalus downwards and inwards, giving rise to flat foot.

The advantages of the obliquity and peculiar arrangement of the posterior calcaneo-astragaloid articulation are seen in walking: (i) for the posterior facet of the calcaneum receives the whole weight of the body when the heel is first placed on the ground; (ii) by the upward pressure of this facet against the astragalus it transfers the weight to the ball of the toes as the heel is raised, the hinder edge of the sustentaculum tali and the anterior and outer part of the upper surface of the calcaneum preventing the astragalus from being displaced too far forward by the superincumbent weight; and (iii) the calcaneum serves to suspend the astragalus when, with the heel raised by muscular action, the other foot is being swung forwards.

The **synovial membrane** is the same as that of the astragalo-scaphoid joint. The **arteries** and **nerves** are derived from the same sources as those of the mediotarsal joints.

Fig. 255.—External View of the Ligaments of the Foot and Ankle.


Antero-inferior tibio-fibular ligament
Anterior ligament of ankle-joint
Outer extremity of the interosseous ligament
External calcaneo-scaphoid ligament
Postero-inferior tibio-fibular ligament
Fasciculus of posterior ligament of ankle
Posterior fasciculus of external lateral ligament
Dorsal cubo-scaphoid ligament
Internal calcaneo-cuboid
Dorsal calcaneo-cuboid
External calcaneo-astragaloid ligament
Middle fasciculus of external lateral ligament of the ankle

(b) The Articulations of the Anterior Part of the Tarsus

These include (i) the cubo-scaphoid; (ii) scapho-cuneiform; (iii) intercuneiform; and (iv) cubo-cuneiform joints.

(i) *The Cubo-scaphoid Union*

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The ligaments which unite the cuboid and scaphoid are:

Dorsal. Plantar. Interosseous.

The **dorsal cubo-scaphoid ligament** (fig. 256) runs forwards and outwards from the outer end of the dorsal surface of the scaphoid to the middle third of the inner border of the cuboid on its dorsal aspect, passing over the posterior external angle of the external cuneiform bone. It is wider externally.

The **plantar cubo-scaphoid ligament** is a well-marked strong band, which runs forwards and outwards, from the plantar surface of the scaphoid to the depression on the inner surface of the cuboid, and slightly into the plantar surface just below it.

The **interosseous cubo-scaphoid ligament** is a strong band which passes between the apposed surfaces of these bones from the dorsal to the plantar ligaments. Some of its posterior fibres reach the plantar surface of the foot behind the cubo-scaphoid ligament, and radiate outwards and backwards over the inner border of the cuboid to blend with the anterior extremity of the short calcaneo-cuboid ligament.

(ii) *The Scapho-cuneiform Articulation*

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The ligaments uniting the scaphoid with the three cuneiform bones are:—

Dorsal. Plantar.
Internal.

The **dorsal scapho-cuneiform ligament** is very strong, and stretches as a continuous structure on the dorsal surface of the scaphoid, between the tubercle of the scaphoid on the inner side, and the dorsal cubo-scaphoid ligament externally, passing forwards and a little outwards to the dorsal surfaces of the three cuneiform bones.

The **internal scapho-cuneiform ligament** is a very strong thick band which connects the tubercle of the scaphoid with the inner surface of the internal cuneiform bone. It is continuous with the dorsal and plantar ligaments. Its lower border touches the tendon of the *tibialis posticus.*

The **plantar scapho-cuneiform ligament** forms, like the dorsal, a continuous structure extending between the plantar surfaces of the bones. Its fibres pass forwards and outwards. It is in relation below with the tendon of the *tibialis posticus.*

It must be noticed that the expanded tendon of insertion of the *tibialis posticus*, and the ligaments uniting the scaphoid with the cuboid and cuneiform bones pass forwards and outwards, while the *peroneus longus* tendon and the ligaments uniting the first and second rows of bones, except the inner half of the dorsal astragalo-scaphoid ligaments, pass forwards and inwards. This arrangement is admirably adapted to preserve the arches of the foot, and especially the transverse arch. Had these tendons and ligaments run directly forward, all the strain on the transverse arch would have fallen on the interosseous ligaments, but as it is, the arch is braced up by the above-mentioned structures.

(iii) *The Intercuneiform and* (iv) *The Cubo-cuneiform Articulations*

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The uniting ligaments of these bones are divided into three sets:

Dorsal. Plantar.
Interosseous.

The **dorsal ligaments** are three in number, two connecting the three cuneiform bones, and a third uniting the external cuneiform with the cuboid. They pass between the contiguous margins of the bones, and are blended behind with the dorsal ligaments of the cubo-scaphoid and scapho-cuneiform joints.

The **plantar ligaments** are two in number: a very strong one passes outwards and forwards from the outer side of the base of the internal cuneiform to the apex of the middle cuneiform, winding somewhat to its outer side. The second connects the apex of the external cuneiform with the anterior half of the inner surface of the cuboid along its plantar border, joining with the plantar scapho-cuboid ligament behind.

The **interosseous ligaments** are three in number. They are strong and deep masses of ligamentous tissue which connect the middle cuneiform with the internal and external cuneiform bones, and the external cuneiform with the cuboid; occupying all the non-articular portions of the apposed surfaces of the bones. The ligaments extend the whole vertical depth between the middle cuneiform and the external, and the external cuneiform and the cuboid, and blend with the dorsal and plantar ligaments; they are situated in front of the articular facets, and completely shut off the synovial cavity behind from that in front. The ligament between the internal and middle cuneiform bones occupies the inferior and anterior two-thirds of the apposed surfaces, and does not generally extend high enough to separate the synovial cavity of the anterior tarsal joint from that of the second and third metatarsal and cuneiform bones. If it does extend to the dorsal surface, it divides the facets completely from one another, making a seventh synovial sac in the foot.

The **synovial cavity** will be described later on.

The **arterial supply** is from the metatarsal and plantar arteries.

The **nerves** are derived from the anterior tibial, and internal and external plantar.

The **movement** permitted in these joints is very limited, and exists only for the purpose of adding to the general pliancy and elasticity of the tarsus without allowing any sensible alteration in the position of the different parts of the foot, as the medio-tarsal and calcaneo-astragaloid joints do. It is simply a gliding motion, and either deepens or widens the transverse arch. The external cuneiform being wedged in between the others is less movable, and so forms a pivot upon which the rest can move. The movement is more produced by the weight of the body than by direct muscular action; and of the muscles attached to this part of the tarsus, all deepen the arch save the tibialis anticus, which pulls the internal cuneiform up, and so tends to widen it.

(*c*) THE MEDIO-TARSAL OR TRANSVERSE TARSAL JOINTS

The articulations of the anterior and posterior portions of the tarsus, although in the same transverse line, consist of two separate joints, viz. (i) an inner, the astragalo-scaphoid, which communicates with the anterior calcaneo-astragaloid articulation; and (ii) an outer, the calcaneo-cuboid, which is complete in itself. The movements of the anterior upon the posterior portions of the foot take place at these joints simultaneously. It will be most convenient to deal with the joints separately as regards the ligaments; while the arteries, nerves, and movements will be considered together.

(i) *The Astragalo-scaphoid Articulation*

Class.—*Diarthrosis.* **Subdivision.**—*Enarthrodia.*

This is the only ball-and-socket joint in the tarsus. It communicates with the anterior calcaneo-astragaloid articulation, and two of the ligaments which close it in do not touch the astragalus, but pass from the calcaneum to the scaphoid. The uniting ligaments are:—

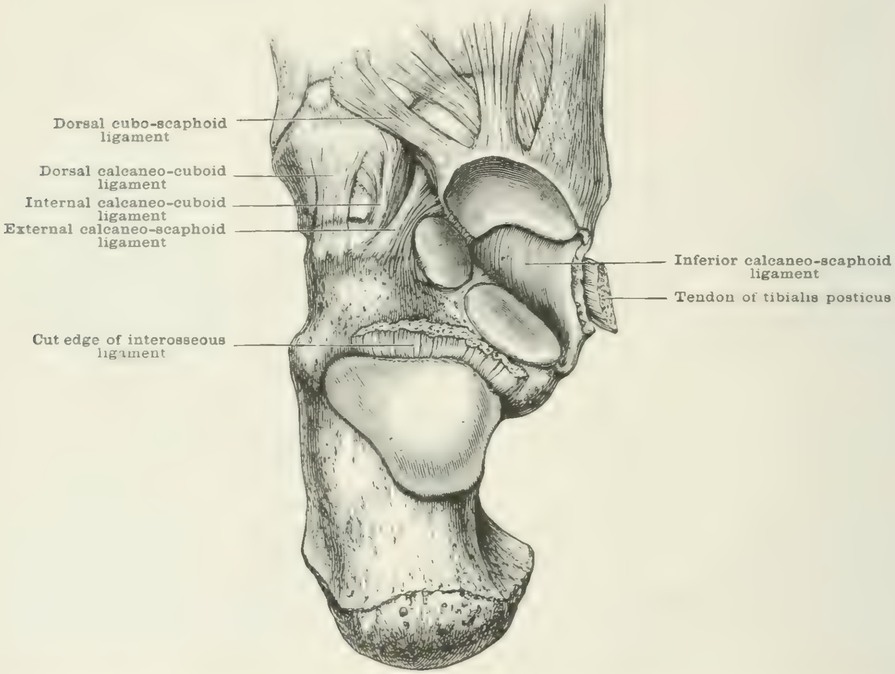
External calcaneo-scaphoid.
Inferior calcaneo-scaphoid.
Astragalo-scaphoid.

The **external calcaneo-scaphoid** has been already described (page 283).

The **inferior calcaneo-scaphoid ligament** (figs. 256 and 257) is an exceedingly dense thick plate of fibro-elastic tissue. It extends from the sustentaculum tali and the under surface of the calcaneum in front of a ridge curving outwards to the anterior tubercle of that bone, to the whole width of the under surface of the scaphoid, and also to the inner surface of the scaphoid behind the tubercle. Internally it is blended with the anterior portion of the internal lateral ligament of the ankle, and externally with the lower border of the external calcaneo-scaphoid ligament. It is thickest along the inner border. Its upper surface loses the well-marked fibrous appearance which the ligament has in the sole, and becomes smooth and faceted. In contact with the under surface of the ligament the tendon of the *tibialis posticus* passes, giving considerable support to the head of the astragalus by assisting the power and protecting the spring of the ligament. The fibres of the ligament run forwards and inwards.

The **astragalo-scaphoid ligament** is a broad, thin, but well-marked layer of fibres which passes from the dorsal and external surfaces of the neck of the astragalus to the whole length of the dorsal surface of the scaphoid. Many of the fibres converge to their insertion on the scaphoid. The fibres low down on the outer side blend a little way from their origin with the upper edge of the external calcaneo-scaphoid ligament, and then pass forwards and inwards to the scaphoid; those next above pass obliquely and with a distinct twist over the upper and outer side of the head of the astragalus to the centre of the dorsum of the scaphoid, overlapping fibres from the inner side of the astragalus as well as some from the anterior ligament of the ankle-joint.

FIG. 256.—VIEW OF THE FOOT FROM ABOVE, WITH THE ASTRAGALUS REMOVED TO SHOW THE INFERIOR AND EXTERNAL CALCANEO-SCAPHOID LIGAMENTS.


Dorsal cubo-scaphoid ligament
Dorsal calcaneo-cuboid ligament
Internal calcaneo-cuboid ligament
External calcaneo-scaphoid ligament
Cut edge of interosseous ligament
Inferior calcaneo-scaphoid ligament
Tendon of tibialis posticus

Synovial membrane.—The astragalo-scaphoid is lined by the same synovial membrane as the anterior calcaneo-astragaloid joint.

(ii) *The Calcaneo-cuboid Articulation*

Class.—*Diarthrosis.* **Subdivision.**—*Saddle-shaped Arthrodia.*

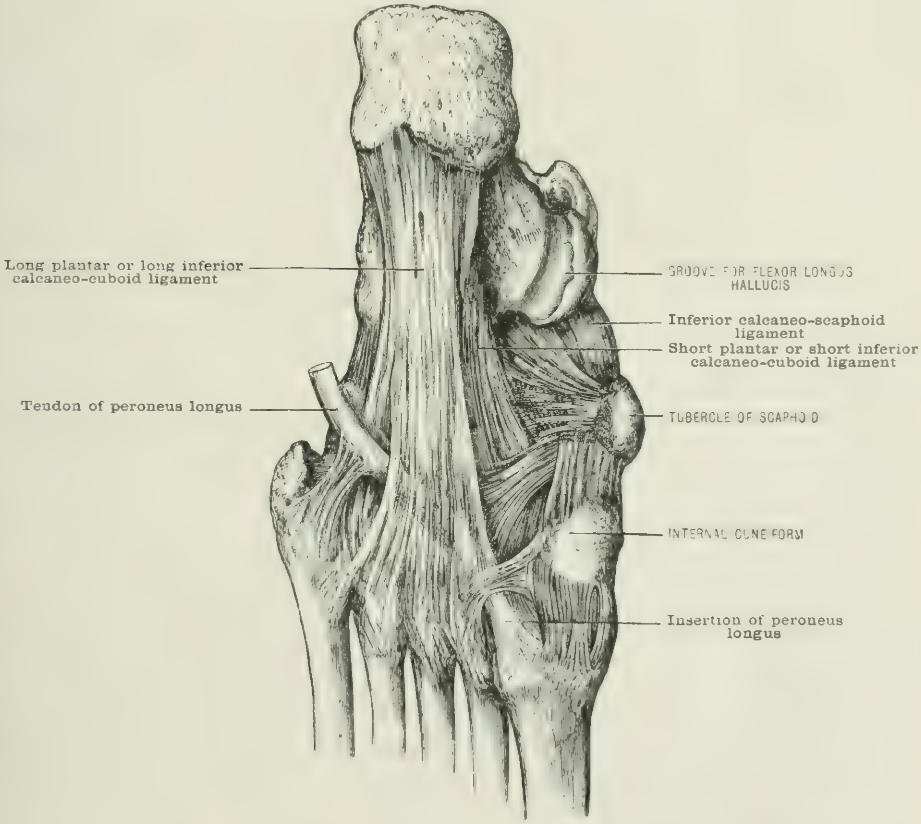
The ligaments which unite the bones forming the outer part of the medio-tarsal joint are:—

Internal or interosseous calcaneo-cuboid.	Dorsal calcaneo-cuboid.
Long inferior calcaneo-cuboid.	Short inferior calcaneo-cuboid.

The **internal** or **interosseous calcaneo-cuboid ligament** (fig. 256) is a strong band of fibres attached to the os calcis along the inner part of the non-articular ridge above the articular facet for the cuboid, and also to the upper part of the internal surface close to the articular margin, and passes forwards to be attached to the depression on the internal surface of the cuboid, and also to the rough angle between the internal and inferior surfaces. At the calcaneum this ligament is closely connected with the external calcaneo-scaphoid ligament. Towards the sole it is connected with the short inferior calcaneo-cuboid ligament, and superiorly with the dorsal calcaneo-cuboid.

The **dorsal calcaneo-cuboid** (fig. 256) is attached to the dorsal surfaces of the two bones, extending low down externally to blend with the outer part of the short plantar ligament. Over the inner half, or more, the ligament stretches some distance beyond the margins of the articular surfaces, reaching well forwards upon the cuboid to be attached about midway between its anterior and posterior borders; but towards the outer side, the ligament is much shorter, and is attached to the cuboid behind its tubercle.

Fig. 257.—Ligaments of the Sole of the Left Foot.


Long plantar or long inferior calcaneo-cuboid ligament
Tendon of peroneus longus
GROOVE FOR FLEXOR LONGUS HALLUCIS
Inferior calcaneo-scaphoid ligament
Short plantar or short inferior calcaneo-cuboid ligament
TUBERCLE OF SCAPHOID
INTERNAL CUNEIFORM
Insertion of peroneus longus

The **long inferior calcaneo-cuboid** (the **long plantar**) (fig. 257) is a strong dense band of fibres which are attached posteriorly to the whole of the under surface of the calcaneum between the posterior tubercles and the rounded eminence (the anterior tubercle) at the anterior end of the bone. Most of its fibres pass directly forwards, and are fixed to the outer two-thirds or more of the oblique ridge behind the peroneal groove on the cuboid, while some pass further forwards and inwards, expanding into a broad layer, and are inserted into the bases of the second, third, fourth, and inner half of the fifth metatarsal bones. This anterior expanded portion completes the canal for the *peroneus longus tendon*, and from its under surface arise the *adductor hallucis* and the *flexor brevis minimi digiti* muscles.

The **short inferior calcaneo-cuboid** (**short plantar**) (fig. 257) is attached to the rounded eminence (anterior tubercle) at the anterior end of the under surface of the calcaneum, and to the bone in front of it, and then takes an oblique course forwards and inwards, and is attached to the whole of the depressed inferior surface of the cuboid behind the oblique ridge, except its outer angle. It is strongest near its outer edge, and is formed by dense strong fibres.

The **synovial membrane** is distinct from that of any other tarsal joint.

The **arterial supply** of the medio-tarsal joints is from the anterior tibial, from the tarsal and metatarsal branches of the dorsalis pedis, and from the plantar arteries.

The **nerve-supply** of the medio-tarsal joints is from the external division of the anterior tibial, and occasionally from the musculo-cutaneous or external plantar.

The **movements** which take place at the medio-tarsal joints are mainly flexion and extension, with superadded lateral and rotatory movements. Flexion at these joints is simultaneous with extension of the ankle, and *vice versâ*. Flexion and extension do not take place upon a transverse, but round an oblique axis which passes from within outwards, and somewhat backwards and downwards through the astragalus and calcaneum.

Combined with flexion and extension is also some rotatory motion round an antero-posterior axis which turns the inner or outer border of the foot upwards. There is also a fair amount of **lateral motion** whereby the foot can be inclined inwards (i.e. adducted) or outwards (i.e. abducted).

These movements of the medio-tarsal joint occur in conjunction with those of the ankle and calcaneo-astragaloid joints. Rotation at the calcaneo-astragaloid joint is, however, round a vertical axis in a horizontal plane, and so turns the toes inwards or outwards; whereas at the medio-tarsal union, the axis is antero-posterior and the inner or outer edge of the foot is turned upwards. Gliding at the calcaneo-astragaloid joint elevates or depresses the edge of the foot, while at the medio-tarsal it adducts or abducts the toes without altering the relative position of the calcaneum to the astragalus.

Thus flexion at the medio-tarsal joint is associated with adduction and inward rotation of the foot, occurring simultaneously with extension of the ankle; and extension at the medio-tarsal joint is associated with abduction and outward rotation, occurring simultaneously with flexion of the ankle.

Flexion and adduction are far more free than extension and abduction, which latter movements are arrested by the ligaments of the sole as soon as the foot is brought into the position in which it rests on the ground.

Although the astragalo-scaphoid is a ball-and-socket joint, yet, owing to the union of the scaphoid with the cuboid, its movements are limited by the shape of the calcaneo-cuboid joint: this latter being concavo-convex from above downwards, prevents rotation round a vertical axis, and also any side-to-side motion except in a direction obliquely downwards and inwards, and upwards and outwards. This is also the direction of freest movement at the astragalo-scaphoid joint. Movement is also limited by the ligamentous union of the calcaneum with the scaphoid. The twisting movement of the foot, such as turning it upon its inner or outer edge, and the increase or diminution of the arch, take place at the tarsal joints, especially the medio-tarsal and calcaneo-astragaloid articulations. Here too those changes occur which, owing to paralysis of some muscles or contraction of others, result in talipes equino-varus, or valgus.

6. THE TARSO-METATARSAL ARTICULATIONS

There may be said to be three articulations between the tarsus and metatarsus, viz:—

(*a*) The Internal, between the inner cuneiform and first metatarsal bones.

(*b*) The Middle, between the three cuneiform and second and third metatarsal bones.

(*c*) The Outer, or *cubo-metatarsal*, between the cuboid and fourth and fifth metatarsal bones.

The **arteries for the tarso-metatarsal joints** are derived: (1) for the internal, from the dorsalis pedis and internal plantar; (2) for the rest, twigs from the metatarsal and deep plantar arches.

The **nerve-supply** comes from the anterior tibial and plantar nerves.

The **movements** permitted at these joints are flexion and extension of the metatarsus on the tarsus; and at the inner and outer divisions, slight adduction and abduction. In the outer, the lateral motion is freer than in the inner joint, and freest between the fifth metatarsal bone and the cuboid. In the inner joint, flexion is combined with slight abduction, and extension with adduction.

There is also a little gliding, which allows the transverse arch to be increased or diminished in depth; the inner and outer two bones sliding downwards, and the two middle a little upwards, when the arch is increased; and *vice versâ* when the arch is flattened.

(*a*) The Internal Tarso-metatarsal Joint

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

A complete capsular ligament unites the first metatarsal with the internal cuneiform, the fibres of which are very thick on the under and inner aspects; those on the outer side pass from behind forwards in the interval between the interosseous ligaments which connect the two bones forming this joint with the second metatarsal. The ligament on the plantar aspect is by far the strongest, and blends at the cuneiform bone with the scapho-cuneiform ligament.

(*b*) The Middle Tarso-metatarsal Joint

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

Into this union there enter the three cuneiform and second and third metatarsal bones, which are bound together by the following ligaments: dorsal, plantar, interosseous.

The dorsal ligaments.—1. Some short fibres cross obliquely from the outer edge of the internal cuneiform bone to the inner border of the base of the second metatarsal bone; they take the place of a dorsal metatarsal ligament which is wanting between the first and second metatarsal bones.

2. Between the middle cuneiform and the base of the second metatarsal bone some fibres run directly forwards.

3. The external cuneiform is connected with (1) the outer corner of the second metatarsal bone by a narrow band passing obliquely inwards; (2) with the third metatarsal by fibres passing directly forwards; and (3) with the fourth metatarsal by a short band passing obliquely outwards to the inner edge of its base.

The plantar ligaments.—A strong ligament unites the internal cuneiform and the bases of the second and third metatarsal bones. The *tibialis posticus* is inserted into these bones close beside it. Other slender ligaments connect the middle cuneiform with the second, and the external cuneiform with the third metatarsal bones.

The interosseous ligaments.—(1) A strong broad interosseous ligament extends between the outer surface of the internal cuneiform, and the inner surface of the base of the second metatarsal bone. It is attached to both bones below and in front of the articular facets, and separates the middle from the internal tarso-metatarsal joint. (2) A second band is attached behind to a fossa on the anterior and outer edge of the external cuneiform and to the interosseous ligament between it and the cuboid, and passes horizontally forwards to be attached to the whole depth of the fourth metatarsal bone behind its internal lateral facet, and to the opposed surfaces of the third and fourth below their lateral articular facets. It separates the middle tarso-metatarsal, and intermetatarsal between the third and fourth bones, from the cubo-metatarsal joint. It is more firmly connected with the third bone than with the fourth. (3) A slender ligament composed only of a few fibres often passes from a small tubercle on the inner and anterior edge of the external cuneiform to a groove on the outer edge of the second metatarsal bone between the two lateral facets.

The **synovial membrane** is prolonged forwards from that of the scapho-cuneiform and inter-cuneiform articulations.

(*c*) THE CUBO-METATARSAL JOINT

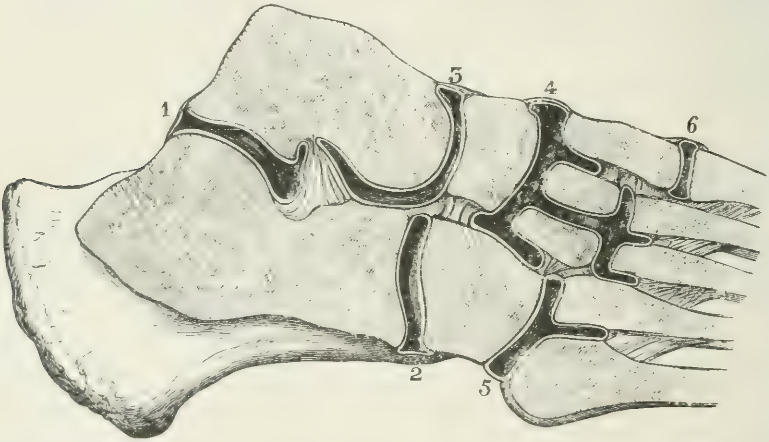
Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The bones comprising this joint are the fourth and fifth metatarsal, and the anterior surface of the cuboid, firmly connected on all sides by

Dorsal. Plantar. Interosseous ligaments.

The **plantar cubo-metatarsal ligament** is a broad, well-marked ligament, which extends from the cuboid behind to the bases of the fourth and fifth metatarsal bones in front. It is continuous along the groove at the base of the fifth metatarsal bone with the dorsal ligament, and as it passes round the outer border of the foot it is somewhat thickened, and may be described as the **external cubo-metatarsal ligament.** On its inner side it joins the interosseous ligaments, thus completing the capsule below. It is not a thick structure, and to see it the long plantar ligament, the peroneus longus, and external slip of the tibialis posticus must be removed; the attachment of these structures to the fourth and fifth metatarsal bones considerably assists to unite them with the tarsus.

FIG. 258.—SECTION TO SHOW THE SYNOVIAL CAVITIES OF THE FOOT.



1. Posterior calcaneo-astragaloid. 2. Calcaneo-cuboid. 3. Anterior calcaneo-astragalo-scaphoid.
4. Tarsal. 5. Cubo-metatarsal. 6. First metatarso-cuneiform.

The **dorsal cubo-metatarsal ligament** is composed of fibres which pass obliquely outwards and forwards from the cuboid to the bases of the fourth and fifth metatarsal bones. They complete the capsule above, and are continuous externally with the external cubo-metatarsal ligament.

The **interosseous ligament** shuts off the cubo-metatarsal from the middle tarso-metatarsal joint. It is attached to the external cuneiform behind, and to the whole depth of the fourth metatarsal behind its internal lateral facet, and to the apposed surfaces of the third and fourth bones below their articular facets. It is continuous below with the plantar ligament.

The **synovial membrane** is separate from the other synovial sacs of the tarsus, and is continued between the fourth and fifth metatarsal bones.

7. THE INTERMETATARSAL ARTICULATIONS

Class.—*Diarthrosis.* **Subdivision.**—*Arthrodia.*

The bases of the metatarsal bones are firmly held in position by dorsal, plantar, and interosseous ligaments. The first occasionally articulates by means of a distinct facet with the second metatarsal (figs. 183 and 184, Section I).

The **dorsal ligaments** are broad, membranous bands passing between the four outer toes on their dorsal aspect; but in place of one between the first and second metatarsal bones a ligament extends from the internal cuneiform to the base of the second metatarsal bone (page 277).

The **plantar ligaments** are strong, thick, well-marked ligaments which connect the bones on their plantar aspect.

The **interosseous ligaments** are three in number, very strong, and are situated at the points of union of the shaft with the bases of the bones, and fill up the sulci on their sides. They limit the synovial cavities in front of the synovial facets.

The common **synovial membrane** of the tarsus extends between the second and third, and third and fourth bones; that of the cubo-metatarsal joint extending between the fourth and fifth.

The **arterial** and **nerve-supply** is the same as for the tarso-metatarsal joints.

The **movements** consist merely of gliding, so as to allow the raising or widening of the transverse arch. Considerable flexibility and elasticity are thus given to the anterior part of the foot, enabling it to become moulded to the irregularities of the ground.

THE UNION OF THE HEADS OF THE METATARSAL BONES

The **heads of the metatarsal bones** are connected on their plantar aspect by the **transverse ligament,** consisting of four bands of fibres passing transversely from bone to bone, blending with the fibro-cartilaginous or sesamoid plates of the metatarso-phalangeal joints, and the sheaths of the flexor tendons where they are connected with the fibro-cartilages. It differs from the corresponding ligament in the hand by having a band from the first to the second metatarsal bone.

8. THE METATARSO-PHALANGEAL ARTICULATIONS

(*a*) THE METATARSO-PHALANGEAL JOINTS OF THE FOUR OUTER TOES

Class.—*Diarthrosis.* **Subdivision.**—*Condylarthrosis.*

These joints are formed by the concave proximal ends of the first phalanges articulating with the rounded heads of the metatarsal bones, and united by the following ligaments:—

Two lateral. Dorsal. Plantar sesamoid plate.

The **two lateral ligaments** are strong bands passing from a ridge on each side of the head of the metatarsal bone to the sides of the proximal end of the first phalanx, and also to the sides of the sesamoid plate which unites the two bones on their plantar surfaces. On the dorsal aspect they are united by the dorsal ligament.

The **dorsal ligament** consists of loose fine fibres of areolo-fibrous tissue, extending between the lateral ligaments, thus completing a capsule. It is connected by fine fibres to the under surface of the extensor tendons, which pass over and considerably strengthen this portion of the capsule.

The **plantar sesamoid plate** helps to deepen the shallow facet of the phalanx for the head of the metatarsal bone, and corresponds to the glenoid ligament of the fingers. It is firmly connected to the lateral ligaments and the transverse ligament, and is grooved inferiorly where the flexor tendons pass over it. It serves to prevent dorsal dislocation of the phalanx.

The second metatarso-phalangeal joint is a quarter of an inch in front of both the first and third metatarso-phalangeal joints.

The third metatarso-phalangeal joint is a quarter of an inch in front of the fourth, and the fourth three-eighths of an inch in front of the fifth.

The head of the fifth metatarsal is in line with the neck of the fourth.

Thus the outer side of the longitudinal arch of the foot is shorter than the inner; it is also distinctly shallower.

(*b*) The Metatarso-phalangeal Joints of the Great Toe

The metatarso-phalangeal joint of the great toe differs from the rest in the following particulars:—

(1) The bones are on a larger scale, and the articular surfaces are more extensive.

(2) There are two grooves on the plantar surface of the metatarsal bone, one on each side of the median line, for the sesamoid bones.

(3) The sesamoid bones replace the fibro-cartilaginous or sesamoid plate. They are two small hemispherical bones developed in the tendons of the flexor brevis hallucis, convex below, but flat above where they play in grooves on the head of the metatarsal bone; they are united by a strong transverse ligamentous band, which is smooth below and forms part of the channel along which the long flexor tendon plays. They are firmly united to the base of the phalanx by strong short fibres, but to the metatarsal bone they are joined by somewhat looser fibres. Laterally they are connected with the lateral ligaments and the sheath of the flexor tendons. They provide shifting leverage for the *flexor brevis hallucis* as well as for the *flexor longus hallucis.*

The **arteries** come from the digital and interosseous branches; and the **nerves** from the cutaneous digital, or from small twigs of the nerves to the interossei muscles.

The **movements** permitted are: flexion, extension, abduction, adduction, and circumduction.

Flexion is more free than extension, and is limited by the extensor tendons and dorsal ligaments; extension is limited by the flexor tendons, the plantar fibres of the lateral ligaments, and the sesamoid plates. The lateral motion is possible from the shape of the bony surfaces, but is very limited, being most marked in the great toe. It is limited by the lateral ligaments and sesamoid plates.

9. THE INTERPHALANGEAL JOINTS

Class.—*Diarthrosis.* **Subdivision.**—*Ginglymus.*

The articulations between the first and second, and second and third phalanges of the toes are similar to those of the fingers, with this important difference, that the bones are smaller and the joints, especially between the second and third phalanges, are often ankylosed. The ligaments which unite them are:—

Two lateral. Dorsal. Glenoid ligament.

The **two lateral** ligaments are well marked, and pass on each side of the joints from a little rough depression on the head of the proximal, to a rough border on the side of the base of the distal phalanx of the joint.

The **dorsal ligament** is thin and membranous, and extends across the joint from one lateral ligament to the other beneath the extensor tendon, with the deep surface of which it is connected, and by which it is strengthened.

The **glenoid ligament** covers in the joint on the plantar surface. It is a fibro-cartilaginous plate, connected at the sides with the lateral ligaments, and with the bones by short ligamentous fibres; the plantar surface is smooth, and grooved for the flexor tendons.

The **arteries** and **nerves** are derived from the corresponding digital branches.

The only **movements** permitted at these joints are flexion and extension.

At the interphalangeal joint of the great toe there is very frequently a small sesamoid bone which plays on the plantar surface of the first phalanx, in the same way as the sesamoid bones of the metatarso-phalangeal joint play upon the plantar surface of the head of the metatarsal bone.

Morphology of Ligaments

The various ligaments of the human body have, in very many instances, been evolved as the result of secondary changes in muscles adjacent to joints. In a few instances, ligaments represent the degenerate remnants of cartilaginous and bony elements. Capsular ligaments are in most joints derived from the periosteum, but they may be strengthened by the incorporation of tendons detached from adjacent muscles.

Muscles arising from, or inserted into bones in the immediate vicinity of a joint tend to become metamorphosed into tendon near their attachments, and a comprehensive study of **myology** in low vertebrate forms indicates that there is associated with this tissue-change a tendency for the muscle to alter its point of attachment; hence a muscle originally inserted below a joint may eventually come to have its insertion above the joint. In the same way, a muscle arising above a joint may, as a result of altered environment, shift its origin to some point below the joint. To this change of position the term **migration of muscles** has been applied. In many instances a portion of the muscle equivalent to the distance between the original and the acquired attachment persists as a fibrous band and fulfils the function of a ligament. This is well seen in the knee-joint, where the internal lateral ligament is derived from the **adductor magnus**, this muscle having shifted its insertion from the tibia to the femur. In the same way the external lateral ligament represents the tendon of the **peroneus longus**, which has migrated from the femur to the head of the fibula.

One of the most remarkable examples of a tendon divorced in this way is the ligamentum teres in the hip-joint. This curious structure was in all probability the tendon of the **pectineus**, which has been detached from the muscle in consequence of the profound alterations which have taken place in the limb during its evolution.

Among other ligaments derived in a similar way from muscles may be mentioned the greater sacro-sciatic ligament. This was originally the tendon of origin of the **biceps femoris**. (H. Morris, "A Note on Three Points in Anatomy," Med. Times and Gazette, April 7, 1877, p. 361.) The lesser sacro-sciatic is derived from the fibrous retrogression of portions of the **coccygeus**. The sacro-coccygeal ligaments represent the muscles which lift, depress, and wag the tail in those mammals furnished with such an appendage; indeed, these ligaments are occasionally replaced by muscle-tissue.

The coraco-humeral ligament is derived from the original tendon of insertion of the **pectoralis minor**, and not unfrequently the muscle is inserted into the lesser tuberosity of the humerus, the ligament being then replaced by the tendon of the muscle. The coraco-clavicular, rhomboid, and gleno-humeral ligaments are probably derived from modifications of the **subclavius** muscle.

The vertebral column contains several ligamentous structures of great morphological interest. The pulpy substance in the centre of each intervertebral disc is derived from the notochord; the suspensory ligament passing from the tip of the odontoid process to the anterior margin of the foramen magnum is a remnant of the sheath of the notochord, and indicates its position as it passed from the vertebral column into the base of the cranium. The transverse ligament of the atlas (as pointed out by Professor Cleland in 1859 and 1861), is a persistent and functional form of the posterior conjugal ligament uniting the rib-heads in seals and many other mammals, whilst the interosseous ligament of the head of a rib in man is the feeble representative of this structure in the thoracic region of the spine. The ligamentum conjugale costarum was described by Mayer in 1834 (Archives d'Anatomie de Muller). According to Luschka's account of this ligament it would seem as though the posterior superior fibres of the capsule of the costo-central joint represented it in man, rather than the interosseous ligament.

Many of the subcutaneous tracts of fascia and many aponeuroses in the human body are derived from the metamorphosis and retrogression of muscle-tissue.

Why don't you put

SECTION III

THE MUSCLES

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THE Muscles consist chiefly of transversely striated fibres arranged in fasciculi or bundles of various sizes; and also of white fibrous tissue, which forms the flattened cords or sheets, the tendons and aponeuroses, as they are called, by which most of the muscles at one or both ends are attached to the bones or cartilages.

In the account of each individual muscle, it is convenient to divide the description into seven heads, viz.:—1. the name; 2. the shape; 3. the attachments; 4. the structure; 5. the nerve-supply; 6. the action; and 7. the relations. A short account also of the more important variations will be added.

1. The **name** is given for various causes, and frequently when it consists of more than one word, for two or even three causes, viz.: (*a*) the supposed action, e.g. adductor and sartorius; (*b*) the shape, e.g. triangularis and lumbricalis; (*c*) the direction, e.g. rectus (straight), obliquus (slanting); (*d*) the position, e.g. sublimis (near the surface), profundus (far from it), gluteus (in connection with the nates); (*e*) its divisions and complexity, e.g. biceps, triceps, multifidus; (*f*) its size, as magnus, minimus, &c.; (*g*) its attachments, e.g. sterno-cleido-mastoideus.

2. The **shape** is sometimes difficult to define on account of the irregularity of the outline, and curvature of the surfaces of the muscle. Some are narrow and of a flattened cylindrical form, which may be designated ribbon-shaped. Many of these are diminished at their extremities, and may be called fusiform or spindle-shaped. Others are broad, and form sheets of various thicknesses, which, according to their outline, may be described as fan-shaped, rhomboidal, triangular, or quadrilateral. Many, again, are compound muscles with double or multiple origins or insertions, which are called, from this cause, bicipital, trifid, &c. This is often the case when a strong muscle arises from many points of bone, or when a muscle divides into many tendons below to move several small levers, such as the bones of the fingers and toes. A few have tendons intercalated in their length, and are called biventral or digastric muscles. It is in some cases difficult to comprehend why certain muscles, on the one hand, which appear to be separate, are grouped under one name as a compound muscle; and, on the other hand, muscles which might very well be combined are distinguished by separate names. The principle of distinction appears to have been to group muscles which combine to form one belly, and to separate those in which the tendons alone are united.

3. Of the **attachments**, the more fixed end of the muscle is usually called the **origin**, the more movable the **insertion**. In enumerating the various points of

attachment, it is very necessary to bear in mind not only those to bone and cartilage, but also those to the fibrous septa and aponeuroses which lie between and around the muscles. Such attachments are best seen when the area of bone surface available for origin or insertion is small. By this means a very great extension is given to this area, and a small bony process, such as the inner condyle of the humerus, is able to give a firm resistance to the traction of many strong muscles.

4. The **structure** will include not only the direction and curvature of the fleshy fibres, and the extent of fibrous tissue by which these fibres arise or are inserted; but also the internal arrangement of tendons and muscular fibre, which is often of a somewhat complicated character. The simplest structure of all is that of muscles with no tendons, in which the fleshy fibres run parallel from one end to the other. Many of the small muscles of the face are of this character. The sterno-mastoid and sartorius are examples also of muscles in which the parallel fleshy fibres form nearly the whole of the structure. It will be found that in these muscles, on account of the number of joints passed over and the distance of the line of the muscle from the axes of these joints, the range of movement is very great. In most parts of the body, however, there would be a great waste of fleshy fibre if this arrangement prevailed. Roughly speaking, we may say, that when fleshy fibres contract fully, their length is diminished by one half. Now, if the distance between the movable points of the skeleton which are joined by the muscles cannot be lessened by this amount, it is obvious that some of the contractile power of the muscle would be wasted. When, therefore, the movable points of the skeleton bridged by a muscle can only be approximated through a limited space, it will be found that the parallel fleshy bundles are about twice the length of this space, and that the rest of the muscle consists of inextensible tendon, which acts simply as a ligament to attach the contractile muscle to the bones. But this addition of tendon to the fleshy part of the muscle is effected in various ways. The simplest plan is that in which the addition is made at one end or the other of the muscle. The palmaris longus is to some extent an example of such an arrangement. By examining the bones it will be seen that the front of the carpus cannot be approximated to the internal condyle of the humerus by more than three inches. The fleshy bundles are, therefore, of about twice this length, and they are accumulated towards the upper end of the muscle, while the rest of its length is occupied by a long tendon. A more common arrangement is for the short fleshy fibres to arise in succession along the surface of a long bone or from an intermuscular septum, and to pass in parallel lines to the end and side of a long tendon, which gradually thickens with the increase of the number of the fibres inserted into it. Such a muscle is like a feather, of which the quill with its diminishing upper extremity will represent the tendon, and the barbs upon one side of it the fleshy fibres. Hence this arrangement is called *penniform*, from *penna*, a feather (fig. 259). This form is found when considerable power is required, but with only a small range of movement. To appreciate fully the effect of such a muscle, we should in our imagination take all the short parallel fibres and place them side by side at the end of the tendon. The muscle would then be converted into a very thick and short fleshy mass with a very long tendon.

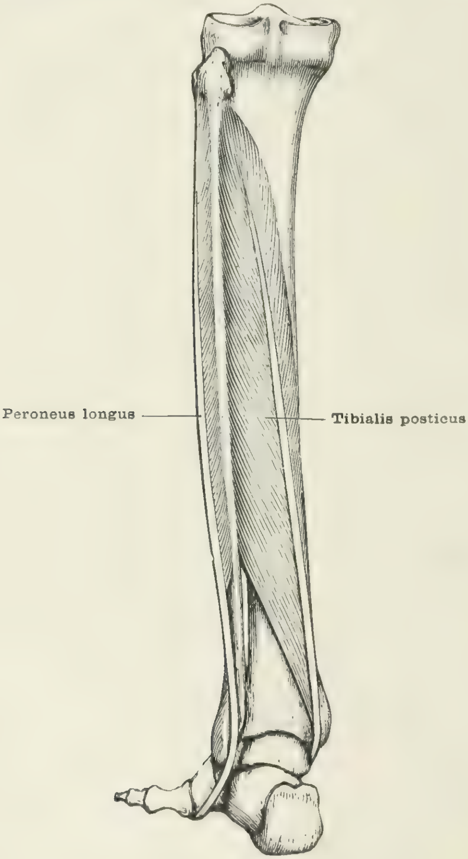
Frequently a muscle arises in two lines from the adjacent surfaces of two bones, from which two sets of parallel fibres converge upon a tendon which runs down in the interval between the bones. This arrangement resembles a feather with barbs on either side of the quill, and is called *bipenniform*. Examples of both these forms are found in the leg. The peronei arising from the fibula alone are penniform, while the tibialis posticus and soleus, arising from both tibia and fibula, are bipenniform.

In some cases a further complication is introduced by the origin of a muscle from both sides of several fibrous septa, as well as from the intermediate surfaces of the bone to which the septa are attached. The insertion may also be of the same character. A good example of this, which is called the *multipenniform* arrangement, is the deltoid, a very powerful muscle with a short range of movement.

In some few cases the tendon is intercalated between two fleshy masses. Such muscles are called **biventral.** The central tendon may represent a bony structure found in lower Vertebrata; and the two bellies may sometimes be fairly regarded as distinct muscles, e.g. those of the digastric muscle. In some cases the central tendon may be of some service in preventing the pressure upon subjacent tissues which would occur if the muscle were at this point fleshy and free to thicken as it contracted. For example, it has been suggested that the central tendon of the omo-hyoid prevents that muscle from compressing the great vessels of the neck as it crosses them beneath the sterno-mastoid. In one muscle, the rectus abdominis, several of these tendinous intersections are found.

5. **Nerve-supply.**—This is of much importance, not only from a medical and surgical point of view, when the paralysis or spasmodic contraction of individual muscles has to be accounted for, but also because of the light which it throws upon the actions of muscles, and the assistance which it sometimes gives us in grouping them.

FIG. 259.—DIAGRAM SHOWING PENNIFORM MUSCLE, THE PERONEUS LONGUS; AND BIPENNIFORM, THE TIBIALIS POSTICUS.



6. **Action.**—Most muscles act upon the levers formed by the movable bones and cartilages. It will be convenient, however, first to speak of those which do not act in this manner. When a muscle passes from a fixed point like a bone to a freely movable point such as the under surface of the skin or mucous membrane, it will simply tend to approximate the movable point to the fixed origin. Such muscles are found in abundance in the face, and the azygos uvulæ is a good example of one which acts upon mucous membrane. Again, the fibres of many muscles run in parallel curves, which combine to form a curved band or sheet. The first effect of the contraction of such a muscle will be to straighten or flatten out the curve. If this lies over a convex surface, as is usually the case, the action

of the muscle will be to compress the structures lying in its concavity. The buccinator and abdominal muscles are good examples of this form of muscle. Or if the surface upon which the curved sheet lies is concave, the muscle will tend by its contraction to lift up the soft parts upon its deep or convex surface. As an instance of this we have the influence of the platysma myoides upon the fascia and other structures which overlie the great vascular channels of the neck and the apices of the lungs.

In estimating the effect of muscles acting upon the levers formed by the bones, each of which moves upon a joint as its fulcrum, three points have to be taken into consideration:—(1) the order of lever; (2) the distance from the fulcrum, of the points of application of the force at the insertion of the muscle, and of the resistance to be overcome; and (3) the direction in which the force is applied. It will be found that whereas in most levers employed in mechanics the object aimed at is what is called *mechanical advantage*, i.e. by the application of a small force to overcome a greater resistance; in the human body the object is, on the contrary, by the exertion of a great force through a small space to overcome a small resistance, but at the same time to cause motion through a much greater space, and with a much greater speed. In the three orders of levers, the fulcrum is placed either between the power and the resistance (first order); or at one end, with the power at the other, and the resistance to be overcome between (second order); or at one end with the power in the middle, and the resistance to be overcome at the other end (third order). The power required to overcome the resistance varies inversely with the distance of its point of application from the fulcrum. Where this distance, or the arm of the lever as it is called, is short compared with the arm at which the resistance acts, then the power has to be greater than the resistance, and *vice versâ*. In the first order of levers, if the power and resistance act parallel to one another, there may or may not be a gain of mechanical advantage, according as the arm at which the power acts is greater or less than the arm at which the resistance acts. In the second order of levers there must necessarily be mechanical advantage; and in the third order the power must be greater than the resistance, as it has to act upon a shorter arm, so there will be what may be termed *mechanical disadvantage*.

In the human body there is hardly a single muscle which forms a good example of a lever of the second order, for the simple reason that mechanical advantage is of so much less importance than a wide range of movement with its attendant rapidity. The best example that can be given is that of some of the muscles which depress the mandible, e.g. the anterior belly of the digastric, which is inserted into the extremity of the lever formed by that bone, while the resistance to be overcome —viz. the tonic contraction of the masseter, temporal, and internal pterygoid—is exerted at a point much nearer to the fulcrum upon which the mandible turns.

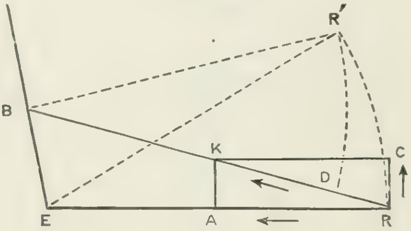
The muscles which are inserted upon the tendo Achillis are often given as an example of this order of lever, when by their contraction they raise the heel and lift up the body, the weight of which acts upon the lever of the foot through the ankle-joint. This would be a good example if another person were to lay hold of the tendo Achillis, and by drawing upon it to raise the individual from the ground. But the fact that the other end of the muscle springs from a part of the mass to be raised alters the conditions, and, as a matter of fact, the muscle, instead of obtaining any mechanical advantage in its action, has to contract with a force four or five times as great as the weight to be raised.

It will be found that most of the muscles belong either to the third order, in which there is necessarily mechanical disadvantage, or to the first order; and in this case, the arm at which the power acts is usually the shorter, so that the power has to be greater than the resistance. In the movements of the forearm about the elbow as a fulcrum, the triceps acting with the very short arm afforded by the projection of the olecranon and overcoming a resistance experienced by the hand at the other end of the radius and ulna, will be a lever of the first order. The brachio-radialis (supinator longus) when used to flex the forearm acts at the lower end of the radius, so as to overcome the weight of the forearm and hand, which will act through a centre of gravity, which is about the middle of the radius, and therefore much nearer to the fulcrum at the elbow. It therefore forms a lever of the second order. If its angle of insertion were not so very small, the muscle would thus obtain a considerable mechanical advantage. This extreme obliquity, however, actually places the muscle in a condition of mechanical disadvantage. Lastly, the biceps and brachialis anticus are both of them good examples of the third order of lever, when they act by their insertion close to the fulcrum of the elbow to flex the forearm, the centre of gravity of which is much farther from the joint.

The *direction* of the tendon at its point of insertion is of great importance in estimating the effect of the contraction of any muscle. It is rarely perpendicular to its lever. There is, therefore, in nearly every case, a considerable loss of mechanical advantage; but it should be remembered that this is more than counterbalanced by important gains. In the first place, the range and rapidity of movement are greatly increased for a given contraction of the muscle; and in the second place a power is also produced by which the articular ends of the bones connected by the muscle are pressed together, so that the tendency to dislocation of the joint is diminished. A third advantage is the compactness given to the limb by the tendons being placed in close apposition to the bones, an object which could not be attained unless their insertions were very oblique.

Take the case of the brachio-radialis flexing the forearm. In the adjoining diagram let E be the elbow, B E the humerus, E R the radius, and B R the line of the brachio-radialis. To estimate how much of the contracting force of the muscle is actually expended in flexing the forearm, all that is necessary is to take any point K in B R, to draw K A perpendicular to E R, and form a rectangle R A K C, on R A. If the force of the muscle acting along R B be represented by the line R K, then R C will represent that portion of the force which tends to flex the elbow, and R A the portion which is devoted to compression of the head of the radius against the capitellum of the humerus, so as to strengthen the elbow-joint. Again, let E R′ be the new position of the forearm after the brachio-radialis has contracted. The arc of the circle through which it has moved will be indicated by R R′, a small arc drawn with radius R E, and centre E. Now join R′ to B, and draw another small arc R′ D with centre B and radius R′ B. R D being the difference between B R and B R′, will indicate the amount by which the length of the muscle has diminished during its contraction, and R R′ will represent the space through which the lower end of the radius has moved. A comparison of the lengths of R D and R R′ will show how great has been the gain in range of movement by the oblique insertion of B R. If the muscle had been inserted at right angles to E R, it would, in order to produce the same effect, have had to contract through a space equal in length to R R′. With its oblique insertion a contraction equal in length to R D has sufficed. The gain in range (and therefore in rapidity of movement, for by contracting through the short distance it causes a simultaneous motion through the longer space) may be roughly represented by the fraction $\frac{R\,R'}{R\,D}$. In muscles in which the insertion of the tendon is at a very small angle, the loss of power is proportionately greater, and the gain in speed and range enormous. As instances of this may be mentioned the insertions of the tendons of the phalanges, which produce the comparatively feeble, but exceedingly nimble, movements of the fingers with a very small contraction of the forearm muscles.

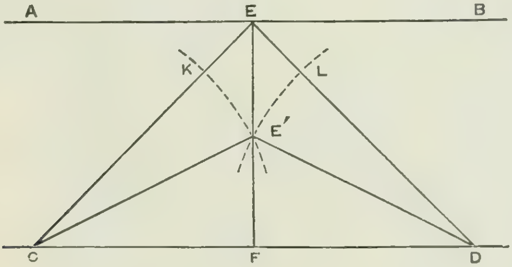
FIG. 260.



In speaking of the direction of the muscles, it should clearly be understood that this refers to the angle of the attachment of the tendon to the lever which has to be moved, and not to the general direction, which is often changed by the passage of the tendon or muscle over projections of bone or under arches of ligament before it reaches its insertion.

The advantage of an oblique insertion may also be illustrated by the action of muscular fibres, which cross one another like the two parts of the letter X in their passage between two parallel bones; e.g. in the external and internal intercostal muscles connecting adjacent ribs, or in the external and internal oblique muscles of the abdomen in their passage from the crest of the ilium to the last rib. If the muscles connecting the parallel bones ran at right angles to them, they could only by their contraction diminish the intervening space by one-half; whereas, running obliquely, they produce by their contraction a much greater approximation of the bones. For let A B and C D represent two parallel bones, and E F a muscular fibre running perpendicularly from one to the other. If its full contraction reduced the length of the fibre by one-half, it would merely draw the point E to E′. But suppose that two muscular fibres C E and D E converge at right angles to each other upon the point E; the amount that they will have to contract to draw E to E′ may be readily found by describing the arc of a circle E′ K or E′ L about C or D as a centre, and with C E′ or D E′ as a radius. E K and E L will represent the contraction required; and it is evident that if these oblique fibres contract more strongly, they can bring the bone A B into close apposition with C D.

Fig. 261.



When muscles pass over more than one joint, their action is somewhat more complicated. Usually other muscles are at the same time called into play, so as to fix some of the joints, and enable the muscle to act solely upon others. For example, when the muscles arising above the wrist are used to extend the phalanges of the fingers, it will be found that some of the flexors of the carpus contract so as to fix the wrist. Similarly, if the fingers are flexed in grasping an object, it is easy to feel the tendons of the carpal extensors starting up into firm contraction.

Occasionally the passage of a muscle over two joints is used to obtain very swift and vigorous action. For example, if the long head of the triceps, which extends from the axillary border of the shoulder-blade to the olecranon process, were replaced by an inextensible ligament, which should be tight with the arm down and the elbow flexed, the elevation of the humerus by the deltoid muscle would necessitate a corresponding extension of the elbow. Now put in the place of the inextensible ligament an actively contracting muscle, and it is clear that the combination of this elevation of the arm by the deltoid with contraction of the triceps will produce a much more rapid extension of the elbow, such as is seen in throwing a spear or a stone.

MUSCLES OF THE UPPER EXTREMITY

The first group consists of those which, arising from various parts of the head, neck, and trunk, are inserted into the bones of the shoulder girdle, viz. the clavicle and scapula, or into the humerus. Of this group there are two divisions: the one comprising the muscles which take their origin from the back of the head, neck, and trunk; the other, those which arise from the front and sides of the thorax.

POSTERIOR DIVISION OF THE GROUP OF MUSCLES PASSING FROM THE TRUNK TO THE UPPER EXTREMITY

This division consists of two layers, which lie superficial to the proper back muscles. Overlying these layers is, first, the **superficial fascia,** which is strong, well provided with fat, and continuous with that of the head, neck, axilla, and other adjacent regions; and, secondly, the **deep fascia,** which is thin and forms the sheath of the trapezius and latissimus dorsi muscles. Above and in front, the deep fascia is continuous with the deep cervical fascia; lower down, with the axillary fascia, and that covering the thoracic and abdominal parietes. Internally it is attached to the spines of the vertebræ, and below it blends with the lumbar aponeurosis.

First Layer

Consisting of one muscle—the trapezius.

THE TRAPEZIUS

The **trapezius** (or cucullaris, as it has been called from its resemblance to a cowl = *cucullus*) is named from *τράπεζα*, a table, on account of the four-sided figure formed by the muscles of the two sides. It is a fan-shaped sheet forming an obtuse-angled triangle, the long side of which corresponds with the spine.

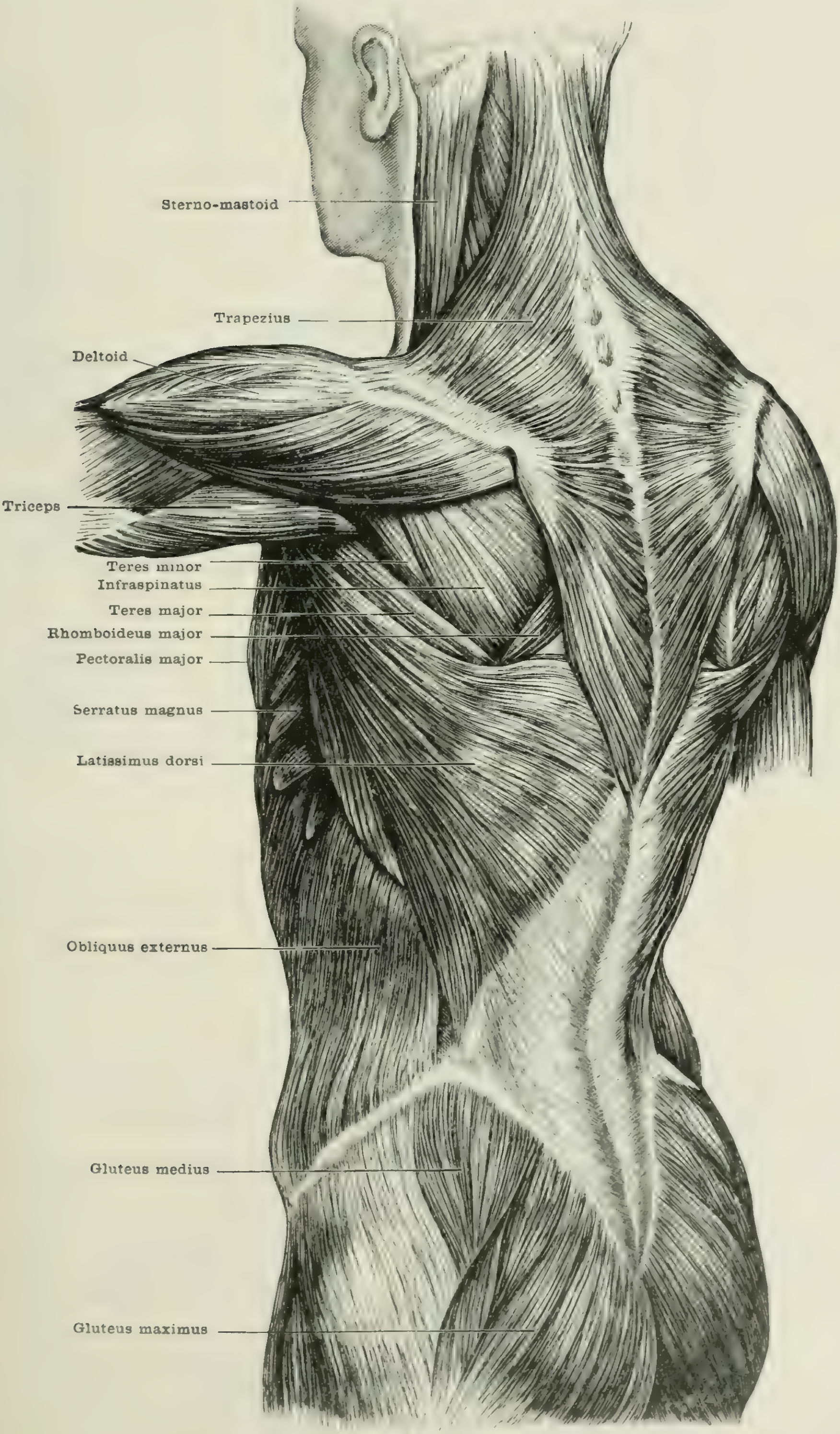
Origin.—(1) The inner third of the superior nuchal line of the occipital bone, and the external occipital protuberance; (2) the posterior border of the ligamentum nuchæ; (3) the spines of the seventh cervical and all the thoracic vertebræ, together with the supraspinous ligament.

Insertion.—(1) The posterior border of the outer third of the clavicle and the adjacent part of its upper surface; (2) the inner edge of the upper surface of the acromion process; (3) the upper border of the spine of the scapula, and a small tubercle at its inner extremity.

Structure.—The origin of the muscle is by short tendinous intermingled with fleshy fibres, except at two places, where the tendinous fibres form a continuous sheet. The first of these is from the middle of the ligamentum nuchæ to the second thoracic spine; here a conspicuous oval aponeurosis is formed by the tendons of the two sides. The second is at the lower acute angle of the muscle where it arises from the lowest thoracic vertebra. The muscular fibres converge from the extensive origin, and just before their insertion, the sheet of the muscle is folded upon itself, to adapt it to the V-shaped process of the shoulder girdle, into which it is inserted by fleshy fibres, except at the inner extremity of the spine of the scapula, where a tendinous sheet plays over the triangular base of that process, before it is inserted into the tubercle at the inner end of the spine. Sometimes a bursa intervenes between this sheet and the triangular surface of the scapular spine.

Nerve-supply.—From the spinal accessory; and from the deep cervical plexus by branches of the third and fourth cervical nerves, which, after communicating

FIG. 262.—FIRST LAYER OF MUSCLES OF THE BACK.


Sterno-mastoid
Trapezius
Deltoid
Triceps
Teres minor
Infraspinatus
Teres major
Rhomboideus major
Pectoralis major
Serratus magnus
Latissimus dorsi
Obliquus externus
Gluteus medius
Gluteus maximus

with the spinal accessory, enter with it the deep surface of the muscle a short distance above the clavicle.

Action.—Its *upper* fibres draw upwards the outer end of the clavicle and the point of the shoulder; and acting from below, they extend the head, flex the neck towards the same side, and turn the face to the opposite side. Its *middle* fibres draw the scapula inwards towards the spine; at the same time they produce a rotation of the scapula on the thorax, by which the point of the shoulder is raised. The *lower* fibres draw the scapula downwards and inwards, and at the same time rotate it so as to raise the point of the shoulder.

Acting as a whole, the muscle draws the scapula towards the middle line of the back, and elevates the shoulder by the rotation it impresses upon the shoulder blade. By drawing the scapula backwards, it gives some help to the pectoralis minor and other muscles which elevate the ribs in forced inspiration. When it takes its fixed point from the shoulder blade and clavicle, as when the hand grasps firmly some immovable object, the muscle will draw the spines of the vertebræ towards the scapula.

The presence of the oval aponeurotic patch may be explained by the fact that the range of movement of the scapula in a horizontal direction backwards and inwards is more limited than when the inward movement is combined with an upward or downward direction. This limitation is due to the ligamentous attachments of the clavicle and shoulder blade.

Relations.—Superficially, the integuments and subcutaneous nerves; deeply, the complexus, splenii, serratus posticus superior, rhomboidei, the vertebral aponeurosis covering the continuations upwards of the erector spinæ, the external intercostals, latissimus dorsi, levator anguli scapulæ, omo-hyoid, scalenus medius and posticus, the supraspinatus, and a small portion of the infraspinatus.

Variations.—Occasionally the upper or the lower part of its origin may fail. The clavicular part of its insertion sometimes extends far forwards upon the clavicle. Frequently fibres pass from its anterior border to the inner end of the clavicle either in front of or behind the sterno-mastoid, forming an arch under which run some of the superficial cervical nerves. This arch may even extend to the sternum. A similar transverse band is occasionally found in the upper part of the posterior triangle, the *transversus nuchæ.* Sometimes a longitudinal band of fibres covers the spinal origin of the trapezius.

SECOND LAYER

Consists of four muscles—the levator anguli scapulæ, rhomboideus minor and major; and the latissimus dorsi.

1. LEVATOR ANGULI SCAPULÆ

The **levator anguli scapulæ** (figs. 263 and 266), named from its action in raising the posterior superior angle of the scapula, is a ribbon-shaped muscle.

Origin.—By four short tendons from the posterior tubercles of the transverse processes of the four upper cervical vertebræ.

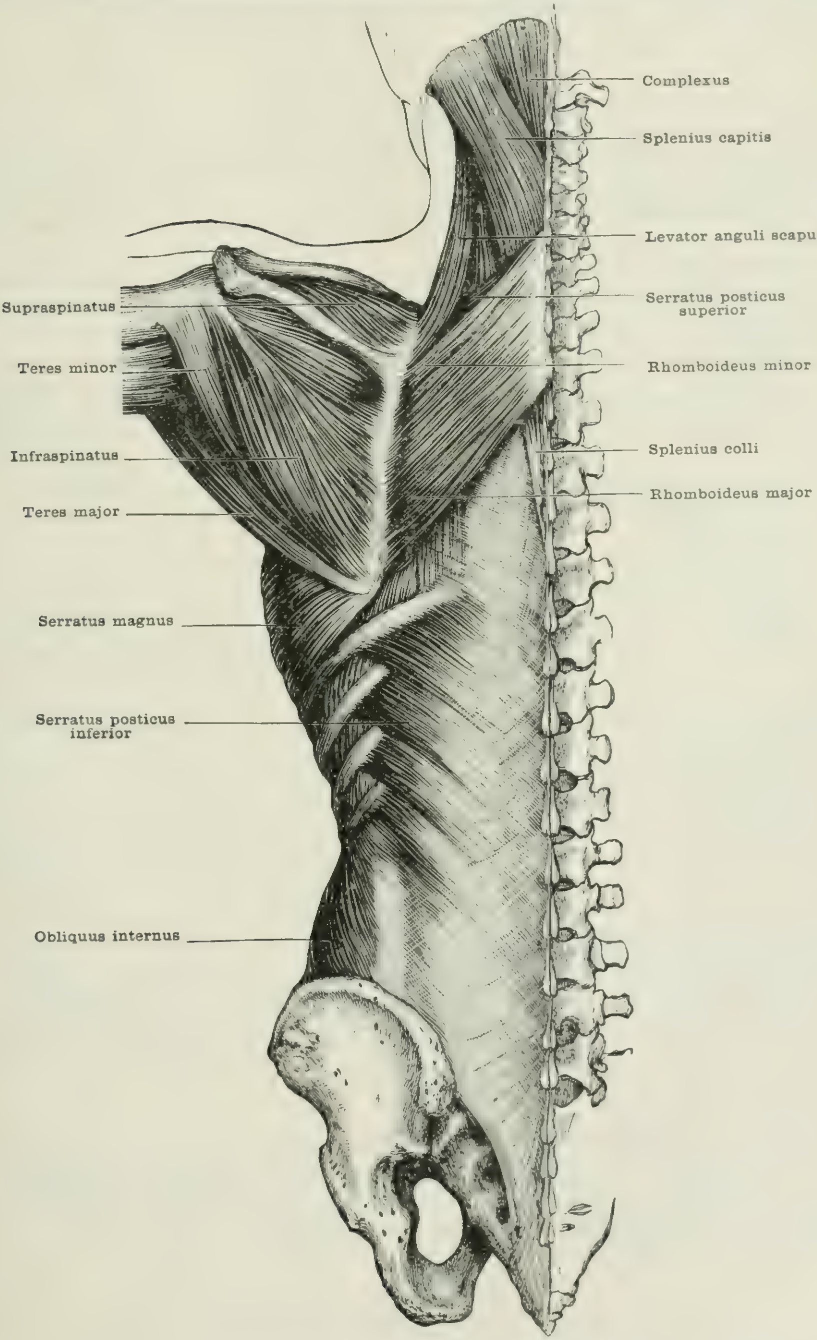
Insertion.—The vertebral border of the scapula opposite the supraspinous fossa.

Structure.—The tendons of origin, which are closely connected with the insertion of the splenius colli, after a short course are succeeded by muscular fasciculi, and these unite to form a thick band of parallel fibres which remain fleshy to their insertion. The plane of the muscle changes as it descends. Above, while lying in the posterior triangle of the neck, its surfaces look outwards and inwards; below, they are directed backwards and forwards.

Nerve-supply.—From the cervical plexus by branches from the third and fourth cervical nerve which enter the front of the outer surface near the origin of the muscle.

Action.—It raises the posterior superior angle of the scapula; but, by causing rotation of that bone, it depresses the point of the shoulder. Taking its fixed point from below, it is an extensor and lateral flexor of the neck.

FIG. 263.—THE LEVATOR ANGULI SCAPULÆ AND RHOMBOIDEI.


Complexus
Splenius capitis
Levator anguli scapulæ
Supraspinatus
Serratus posticus superior
Teres minor
Rhomboideus minor
Infraspinatus
Splenius colli
Rhomboideus major
Teres major
Serratus magnus
Serratus posticus inferior
Obliquus internus

Relations.—Superficially, the deep cervical fascia, the platysma myoides, the sterno-mastoid, the trapezius, the scalenus medius, the internal jugular vein, the spinal accessory nerve, and some of the descending branches of the cervical plexus;

deeply, the splenius colli, the cervicalis ascendens, the serratus posticus superior, and the posterior scapular vessels.

Variations.—The number of cervical vertebræ from which the muscle arises varies, and it may even arise from the mastoid process or occipital bone. It may send slips to the serratus magnus, the serratus posticus superior, and other adjacent muscles; occasionally also to the clavicle and first two ribs.

2 AND 3. RHOMBOIDEI

The **rhomboidei**—named from their shape, which is rhomboidal, or like a parallelogram—are sometimes looked upon as a single muscle, but may be usually separated into the following:—

The **rhomboideus minor,** the lesser and upper of the two, is a four-sided sheet, forming an elongated parallelogram.

Origin.—The lower part of the ligamentum nuchæ, the spines of the seventh cervical and first thoracic vertebræ, and the supraspinous ligament between them.

Insertion.—The vertebral border of the scapula opposite its spine.

Structure.—Its origin and insertion are by short tendinous fibres, between which its fleshy fibres run parallel to one another, downwards and outwards.

Nerve-supply.—From the brachial plexus by a branch of the fifth cervical nerve, which enters its deep aspect near the upper border a short distance above its insertion.

For **action** and **relations,** see the account of the following muscle.

The **rhomboideus major**—the lower and larger of the two muscles—is a broad rhomboidal sheet.

Origin.—The spines of the four or five upper thoracic vertebræ, and the supraspinous ligament between them.

Insertion.—The vertebral border of the scapula opposite the infraspinous fossa.

Structure.—At the origin, it consists of short tendinous fibres, succeeded by parallel fleshy bundles, which pass downwards and outwards to a narrow tendinous expansion which is feebly attached to the scapula over the upper three-fourths of its insertion, but with thick and strong fibres near the inferior angle of that bone.

Nerve-supply.—The same as the preceding, and entering the upper part of the deep surface near its insertion.

Action.—The rhomboidei draw the scapula inwards and backwards towards the middle line, and at the same time upwards. They also rotate the scapula so as to depress the point of the shoulder. In this way they, together with the levator anguli scapulæ, will help in drawing down the arm, after it has been elevated through the rotation of the scapula by the trapezius and serratus magnus.

Acting from the scapula, the rhomboidei will help the trapezius in drawing the middle line of the back towards that bone.

Relations of the two rhomboidei.—Superficially, the trapezius and, at the lower part of the rhomboideus major, the deep fascia, and latissimus dorsi; deeply, the serratus posticus superior, splenius colli, the external intercostals, the posterior scapular vessels, the angles of the upper ribs, and the vertebral aponeurosis covering the upper continuations of the erector spinæ.

Variations.—The rhomboideus minor is frequently absent, and occasionally there is no rhomboideus major. The fibres of the latter muscle may be inserted almost entirely into the lower angle of the scapula. Occasionally its lower fibres join those of the latissimus dorsi, and they have also been found continuous with a part of the teres major. An accessory band may join the rhomboidei from the occipital bone (the occipito-scapularis).

4. LATISSIMUS DORSI

The **latissimus dorsi** (figs. 262 and 269)—named from its being the broadest of the back muscles—is a fan-shaped sheet forming a right-angled triangle, the right angle being contained between its upper and vertebral borders.

Origin.—(1) The five or six lower thoracic spines, and the supraspinous ligament; (2) the lower part of the vertebral aponeurosis (see account of LUMBAR FASCIA, page 408), by which it is attached to the spines of all the lumbar and sacral vertebræ; (3) the posterior third of the outer lip of the crest of the ilium; (4) horizontal lines crossing the outer surface of the last three or four ribs external to their angles (these lines by their lower borders give origin to processes of the external oblique muscle, which thus interdigitates with the latissimus dorsi); and sometimes (5) the dorsal aspect of the inferior angle of the scapula.

Insertion.—The bottom of the bicipital groove of the humerus, as far upwards as the lesser tuberosity.

Structure.—Its first and third parts arise by short tendinous fibres. The origin of the second part from the vertebral aponeurosis is by fleshy fibres in a line which descends obliquely downwards and outwards from the last thoracic spine to the back of the crest of the ilium. Its origin from the ribs and scapula is muscular. The fleshy fibres are of nearly equal length, and they converge upon the tendon in such a way that those which arise from the ribs and crista ilii are inserted highest into the humerus, while those which spring from the thoracic spine are attached to the lower part of the bicipital groove. The broad sheet wraps round the side of the thorax, and is also folded upon itself, so that the anterior surface at the origin becomes the posterior at the insertion. A groove is thus formed, in which lie the outer border of the scapula and the teres major. The tendon of the teres major is usually attached at the borders to that of the latissimus dorsi by strong connective tissue; but a bursa intervenes between them near their insertion.

Nerve-supply.—From the posterior cord of the brachial plexus by means of the long subscapular nerve. This is derived from the sixth and seventh cervical nerves, and enters the muscle upon its deep surface in the lower part of the axilla.

Action.—It draws the humerus backwards, downwards, and inwards; at the same time rotating it inwards. The movement of the arm in swimming is a good example of its action. When the arm is placed close to the side, it will draw the shoulder backwards and downwards.

Acting from the humerus as a fixed point, it is very important in climbing, as it draws the pelvis and lower part of the trunk upwards and forwards towards the arms.

By its costal origin it will assist in forced inspiration when the arm is fixed.

Relations.—Superficially, the trapezius, fasciæ, and integument behind, and the pectoralis major, axillary vessels, and branches of the brachial plexus in front; deeply, the rhomboideus major, the vertebral aponeurosis covering the upward continuations of the erector spinæ muscle, the serratus posticus inferior, external intercostals, external oblique, infraspinatus, serratus magnus, and teres major muscles.

Variations.—It varies in the height of its origin from the spinal column, and also in the number of ribs from which it arises. From its axillary border slips may cross the axilla to the tendon of the pectoralis major, or may cross the great vessels and nerves to the coracoid process or the deep fascia at the upper part of the arm. A slip of fascia or muscle may be continued down from its tendon of insertion to the olecranon in association with the triceps.

ANTERIOR DIVISION OF THE GROUP OF MUSCLES PASSING FROM THE TRUNK TO THE UPPER EXTREMITY

These muscles are arranged in three layers, of which the first two are formed by muscles which arise from the front of the thorax: viz., the pectoralis major in the first layer, and the subclavius and pectoralis minor in the second; the last by a single muscle, the serratus magnus, which takes origin from the side of the thorax.

The **superficial fascia**, which covers all these layers, is but moderately supplied with fat, and is continuous with that of all the adjacent regions. It lies both over and beneath the mammary gland, and sends fibrous septa between its lobules.

In addition to the superficial fascia, there are three other important fasciæ in this region.

1. The **pectoral fascia**, a thin membrane which forms the sheath of the pectoralis major, and is attached to the clavicle above; while below it passes over the free edge of the great pectoral muscle, and there unites with the axillary fascia.

2. The **clavi-pectoral fascia** arises in two sheets from the anterior and posterior borders of the under surface of the clavicle. These sheets unite after enclosing the subclavius muscle, and form a single membrane (the *costo-coracoid*), which, after bridging the space between the subclavius and pectoralis minor, divides again to form the sheath of the pectoralis minor. At the lower border of this muscle, the clavi-pectoral joins the axillary fascia. The costo-coracoid membrane, which is the middle portion of the clavi-pectoral fascia, is of a quadrilateral shape, and is attached above and below to the sheaths of the subclavius and the pectoralis minor muscles; externally, where it blends with the sheath of the axillary vessels, it is very strong; internally, where it joins the fascia covering the front part of the first and second intercostal spaces, it is thin and weak.

3. The **axillary fascia** is a strong membrane which stretches across the triangular floor of the axilla. In front, it joins the pectoral and clavi-pectoral fasciæ; behind, it joins the sheath of the latissimus dorsi; above, it is continuous with the deep fascia of the upper arm, and below with that of the thorax.

The concavity of its surface, which is directed downwards and outwards, is maintained to a great extent by the attachment of the clavi-pectoral fascia above mentioned.

FIRST LAYER

PECTORALIS MAJOR

The **pectoralis major**—named from its being the larger of the two muscles which arise from the front of the chest (*pectus* = breast)—is a thick, triangular, fan-shaped sheet; or, more accurately, it may be likened to the segment of a circle on account of the curved origin, from which all the fibres converge to the upper part of the humerus as a centre.

Origin.—(1) The anterior surface of the inner half of the clavicle and the adjacent part of the sterno-clavicular joint; (2) the side of the front of the sternum, from the sterno-clavicular joint to the lower extremity of the gladiolus; (3) the front of the cartilages of the second to the sixth ribs; (4) a small part of the outer surface of the sixth rib close to its anterior extremity; (5) the upper part of the aponeurosis of the external oblique muscle which forms the front of the sheath of the rectus abdominis.

Insertion.—(1) The external bicipital ridge of the humerus from the greater tuberosity down to the impression for the deltoid; (2) adjacent fibrous structures, especially the tendon of insertion of the deltoid muscle.

Structure.—The **clavicular** portion is distinct from the rest, and might be described as a separate muscle. It forms a thick band of parallel fibres, which, arising tendinous from the clavicle, become almost immediately fleshy, and are inserted into the humerus by short tendinous fibres in front of the rest of the tendon of insertion.

The rest of the muscle (the **sterno-costal portion** as it is usually named) consists of fleshy fibres which, arising directly from the four other parts of the origin enumerated, converge and cross one another to be inserted into the humerus behind the clavicular portion by means of a peculiar tendon.

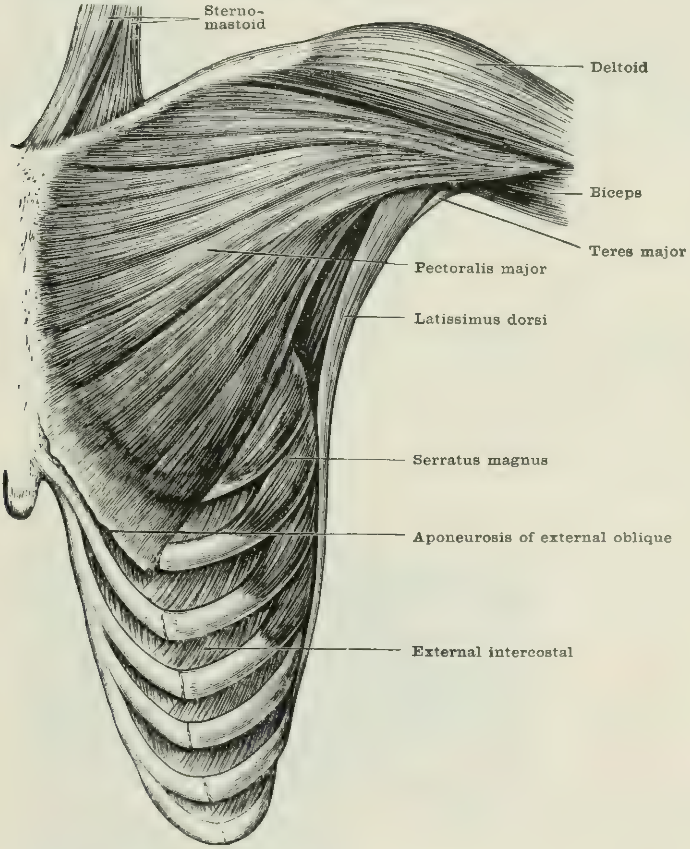
In a vertical section (fig. 271) near the humerus this tendon is seen to be folded upon itself into a compressed horseshoe-shape. The convexity of the folded tendon is directed downwards, and the anterior segment of the horseshoe is shorter than the posterior.

The anterior segment receives the muscular fibres which proceed from that part of the origin of the sterno-costal portion which lies above the third costal cartilage, and with the front of this segment, the insertion of the clavicular portion is closely blended. The posterior segment receives the fibres from the lower part of the sterno-costal portion, the lowest fibres (viz. those from the external oblique aponeurosis) being inserted highest, and the highest (viz. those from the middle of the sternum) being attached to the lower part of the horseshoe, where they become continuous with those forming the anterior segment of the tendon.

In consequence of this arrangement the lower fibres of the muscle disappear from view soon after their origin, and are concealed by the clavicular and upper sterno-costal fibres. This arrangement gives to the anterior border of the axilla a concave outline. Were it not for this decussation, the muscle would be broader and thinner, and would cause an inconvenient and unsightly projection in front of the axilla.

The sterno-costal portion may usually be divided into a superficial and deep plane, the superficial being composed of the sternal and external oblique origin; the deep, of the fibres which spring from the cartilages and the sixth rib.

FIG. 264.—THE PECTORALIS MAJOR AND DELTOID.



Nerve-supply.—From all the nerves of the brachial plexus:—(1) through the external anterior thoracic nerve, which enters the deep surface of the muscle just below the middle of its upper border; and (2) through the internal anterior thoracic, which, after piercing and supplying the pectoralis minor, enters the deep surface of the muscle a little lower down, half-way between its origin and insertion.

Action.—To adduct, flex, and rotate inwards the upper arm. By its clavicular portion it will draw the arm more directly forwards, as in round-hand bowling, while the sterno-costal portion will draw the arm more downwards than forwards. The whole muscle will be used with great force in striking a blow downwards and forwards. When the arm hangs close to the side, the pectoralis major will draw the scapula forwards and downwards, so as to advance and depress the point of the shoulder, as may be seen in a person shivering with cold. When the arm is elevated and fixed, this muscle will draw the front of the chest up to it, as in climbing. It will also raise the upper ribs in forced inspiration.

Relations.—Superficially, the platysma myoides, the mammary gland, and the cutaneous nerves from the descending branches of the cervical plexus, as well as the lateral and anterior perforating branches of the upper intercostals.

Beneath, lie the subclavius, pectoralis minor, and serratus magnus, the fascia covering the external and internal intercostal muscles, the coracoid process, and costo-coracoid membrane, with the structures which pass through the membrane, viz. the cephalic vein, acromio-thoracic vessels, and the external anterior thoracic nerve. Further outwards it forms part of the anterior wall of the axilla, and enters into relation with the biceps, the coraco-brachialis, and the axillary vessels and nerves.

The upper border is separated from the deltoid by the cephalic vein and the humeral branch of the acromio-thoracic artery.

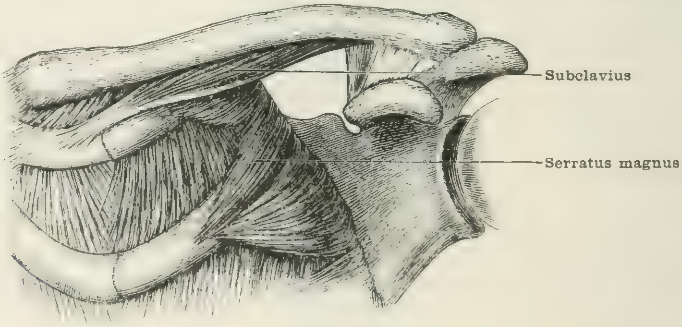
Variations.—The clavicular and sterno-costal portions are often widely separated. They may also be further subdivided into separate bands or sheets, and they may be wholly or partly absent. Occasionally, the muscles of the two sides join across the sternum, or muscular bands may unite the sternal ends of the clavicles. Bands may cross from the axillary border to the latissimus dorsi or the deep fascia of the upper arm ; deeper bands may also pass to the insertion of the pectoralis minor, or the capsule of the shoulder-joint.

SECOND LAYER

1. SUBCLAVIUS

The **subclavius**—named from its position beneath the clavicle (= *clavis*)—is almost cylindrical, but may be more accurately described as a thick sheet of the shape of a low obtuse-angled triangle, the obtuse angle being contained between the clavicular attachment and the inner free border of the muscle.

FIG. 265.—THE SUBCLAVIUS AND THE UPPER PORTION OF THE SERRATUS MAGNUS.



Origin.—The upper and anterior surface of the first rib and its cartilage at their point of junction.

Insertion.—The groove on the lower surface of the clavicle from the rhomboid impression to the conoid tubercle.

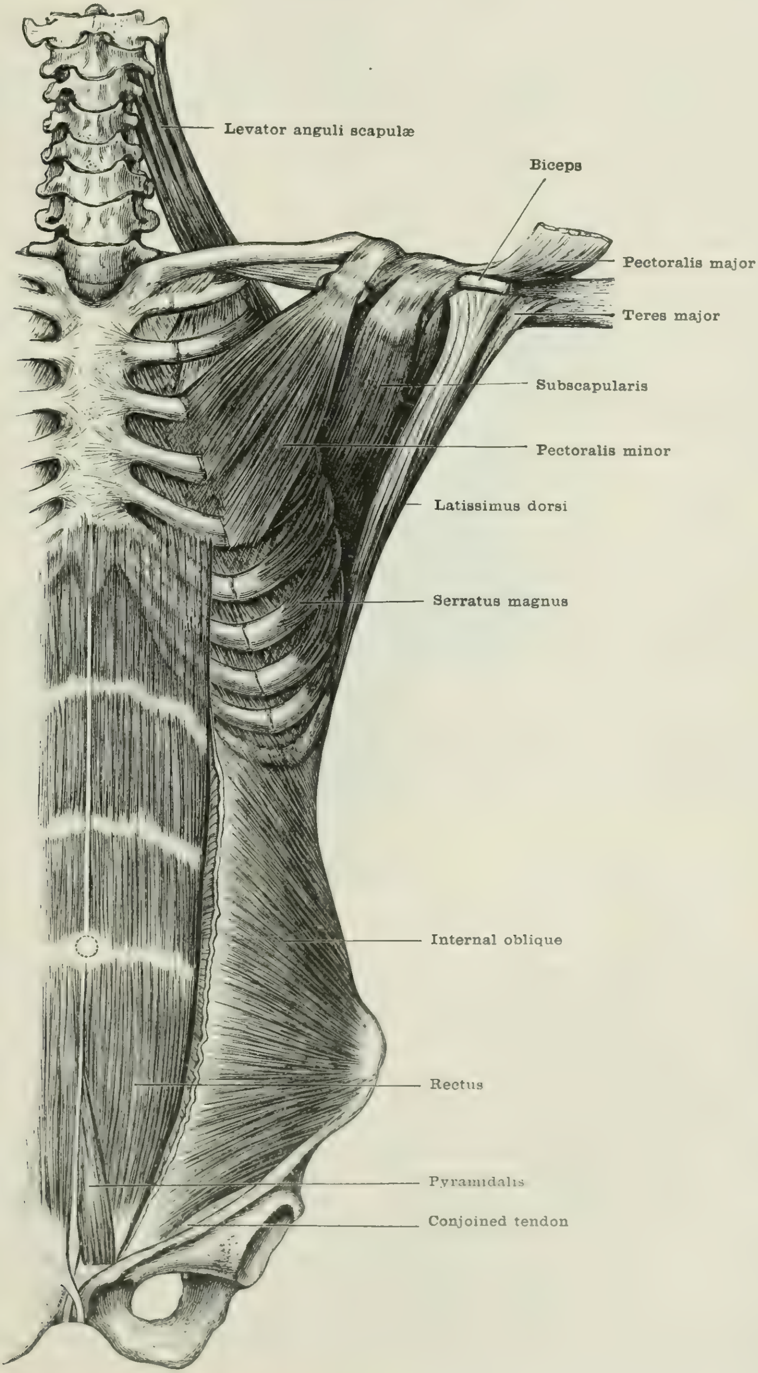
Structure.—It arises by a strong tendon, flattened from before backwards, which lies close to the front of the rhomboid ligament, and is continued for a considerable distance along the lower border of the muscle. Its insertion is by fleshy fibres which radiate upwards, outwards, and a little backwards, in a penniform manner, from this tendon; the inner ascending more vertically, and the outer very obliquely.

Nerve-supply.—From the brachial plexus by a small branch which, arising from the fifth and sixth cervical nerves, passes behind the clavicle and enters the middle of the back of the muscle.

Action.—To draw the outer end of the clavicle, and with it the point of the shoulder, downwards and slightly forwards; but chiefly by pulling the bone inwards to supplement the ligaments which prevent dislocation of the sterno-clavicular joint.

Relations.—In front, the clavi-pectoral fascia and the pectoralis major; behind,

FIG. 266.—THE PECTORALIS MINOR, OBLIQUUS INTERNUS, PYRAMIDALIS, AND RECTUS ABDOMINIS.


Levator anguli scapulæ
Biceps
Pectoralis major
Teres major
Subscapularis
Pectoralis minor
Latissimus dorsi
Serratus magnus
Internal oblique
Rectus
Pyramidalis
Conjoined tendon

the posterior division of the same fascia, the rhomboid ligament, the subclavian vessels, and the brachial plexus.

Variations.—The subclavius may be absent, or its insertion may extend to the coracoid process, transverse ligament, and upper border of the scapula. Occasionally the costo-clavicular portion is separate from the costo-scapular. Again, its origin may extend inwards to the sternum, and the portion which arises from the sternum may be separate from the rest of the muscle.

2. PECTORALIS MINOR

The **pectoralis minor**—named from its being the smaller of the two muscles which arise from the front of the chest—is a fan-shaped or triangular sheet, with its inner edge divided into three teeth.

Origin.—(1) The upper borders and outer surfaces of the third, fourth, and fifth ribs near their anterior extremities; (2) the fascia covering the intercostal muscles in the spaces between these ribs.

Insertion.—(1) The upper surface of the coracoid process of the scapula; (2) the upper part of the tendon of the coraco-brachialis along its inner border.

Structure.—Its origin is by aponeurotic slips, which, after becoming fleshy, converge upwards, outwards, and somewhat backwards, upon the flattened tendon, which is attached chiefly to the coracoid process, but blends for an inch or more below that process with the origin of the coraco-brachialis.

Nerve-supply.—From the inner cord of the brachial plexus (through the eighth cervical nerve) by the internal anterior thoracic, which enters its deep surface near the upper border, the nerve subsequently piercing the muscle to send filaments to the pectoralis major.

Its **action** is to draw downwards and forwards the scapula, depressing at the same time the point of the shoulder. Taking its fixed point from the coracoid process, it draws upwards and outwards the ribs to which it is attached, and so helps in forced inspiration. Its connection with the tendon of the coraco-brachialis will enable it to act slightly as a flexor and adductor of the humerus.

Relations.—Superficially, the pectoralis major; deeply, the external intercostal muscles; and, near its insertion, the axillary vessels and brachial nerves.

Variations.—The origin may extend upwards as far as the second, or downwards to the sixth rib, and it may receive additions from the pectoralis major. It is occasionally altogether absent. Its insertion may be continued over the coracoid process to the capsule of the shoulder-joint, the greater tuberosity of the humerus, or the clavicle.

Third Layer

SERRATUS MAGNUS

The **serratus magnus**—named from its serrated or saw-like anterior border and large size—is an irregular quadrilateral sheet curved to the shape of the side of the thorax. Its anterior attached border has a somewhat sinuous curve, and arises from the side of the thorax by nine or ten digitations or teeth, which, by their saw-like appearance, give the muscle its name. The muscle may be divided into an upper, middle, and lower part.

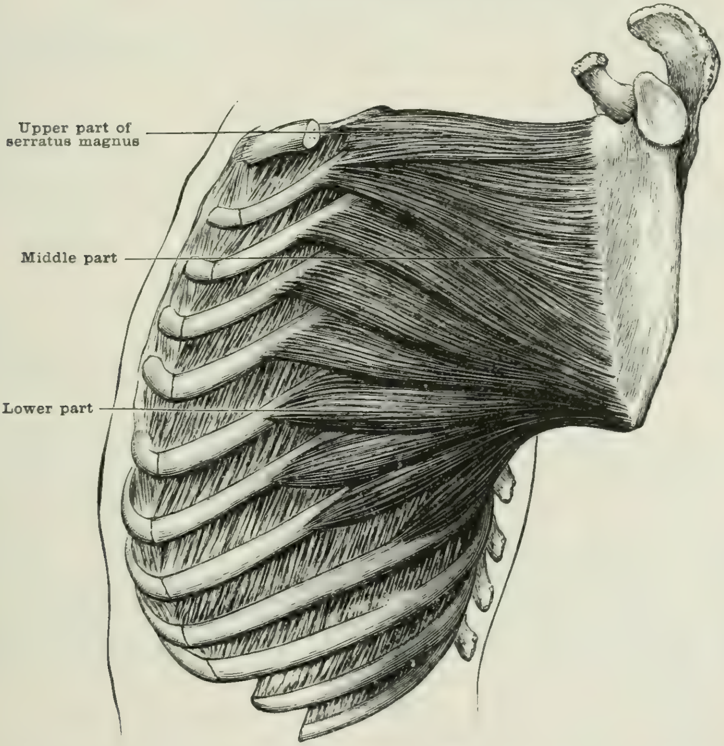
Origin.—**First part,** by two teeth from the middle of the outer surface of the first and second ribs, and from the fascia covering the first intercostal space. **Second part,** by two or three heads from the second, third, and sometimes the fourth ribs upon their outer surface. **Third part,** by far the largest and strongest portion of the muscle, arises from the fourth or fifth to the eighth or ninth ribs by a series of teeth, which are attached in front near the upper border of each rib, and behind to a line running backwards across the outer surface of the rib from its upper to its lower border. These attachments form a curved line with the convexity forwards, the attachment to the sixth rib being the most anterior and prominent.

Insertion.—The **first part** is attached to an oval space upon the venter of the scapula close to the posterior superior angle. The **second part,** to the whole of the vertebral border of the scapula upon its ventral aspect. The **third part** to the large oval space on the venter of the scapula close to its inferior angle.

Structure.—The origin of the muscle is by fleshy or short aponeurotic fibres, and in the first part these fibres converge very slightly towards their fleshy insertion. In the second part they diverge and form a thin sheet attached to the vertebral border of the scapula. In the third part of the muscle the fibres converge fanwise and form a very thick and strong fleshy mass which is inserted directly into the inferior angle of the scapula. At their origin the teeth of this part of the muscle interdigitate with or fit in between those of the origin of the obliquus abdominis externus. All the fibres are curved to adapt themselves to the convex wall of the chest.

Nerve-supply.—From the brachial plexus by the posterior thoracic nerve, which is derived from the fifth, sixth, and seventh cervical nerves. After running down the side of the chest upon the outer surface of the muscle, the nerve is distributed by many branches to the various digitations.

FIG. 267.—SERRATUS MAGNUS.



Action.—By its contraction, this muscle draws forwards the vertebral border of the scapula and, as the third part of it is much the strongest, it will act especially upon the inferior angle, and will rotate the scapula so as to raise the point of the shoulder. It will therefore help the trapezius muscle in raising the shoulder, and it will be brought powerfully into play whenever the shoulder is used in pushing in a forward direction. It is most important, however, in relation to the movements of the arm. In order that the deltoid muscle may raise the humerus, it is necessary that the fulcrum formed by the glenoid portion of the scapula should be held steady. For this reason the scapula extends so far downwards in order that the leverage given to the third and most powerful portion of the serratus may be as great as possible. When the serratus magnus is paralysed, all the efforts of the deltoid to elevate the arm are unsuccessful, and only cause the lower angle of the scapula to project from the back of the thorax. When the arm has been elevated to its full extent by the deltoid, that is, through about a right angle, the rotation of the scapula due to the serratus magnus and trapezius will produce a further elevation through another right angle, and so place the arm in a vertical position. One of the results of the action of this muscle is to keep the lower angle of the scapula in close contact with the wall of the thorax. When the muscle is paralysed, the posterior borders and the inferior angles of the scapulæ project backwards from the thorax like small wings (*scapulæ alatæ*).

Acting from its scapular insertion, the muscle tends to draw the front of the chest towards the scapula, e.g. when it supports the thorax in crawling on the hands and knees. Judging from the direction in which its fibres are inserted into the ribs, most of them can have little if any action in elevating the ribs, as in forced inspiration.

Relations.—Superficially, the pectoralis major and minor, the subscapularis and latissimus dorsi, the subclavian and axillary vessels and the brachial plexus; deeply, the external intercostal muscles, and serratus posticus superior.

Variations.—It may arise as low as the tenth rib; and above, it may receive slips from the cervical transverse processes, or the levator anguli scapulæ. Part or the whole of the muscle may be deficient.

The Second Group comprises the muscles which pass from the scapula to the upper limb, and move the upper arm. Some of the most important adductors, flexors, and extensors belong to the first group; but abduction and rotation in both directions are provided for by the second group.

MUSCLES WHICH PASS FROM THE SCAPULA TO THE UPPER LIMB

These are nine in number, viz. the deltoid, supra-spinatus, infra-spinatus, teres minor, subscapularis, teres major, coraco-brachialis, biceps, and triceps. The two last, however, as they act chiefly upon the forearm, will not be described in this group.

The **superficial fascia** covering the muscles contains but little fat. The **deep fascia** is thin where it covers the front of the deltoid, and is continuous with that which invests the pectoralis major and the axillary fascia. Behind, it is thicker, especially where it covers in the lower part of the infra-spinatus. Below, it blends with the deep fascia of the upper arm. Above, it is connected with the clavicle and scapula above the upper attachment of the deltoid.

It is also connected, either directly or by strong intermuscular septa, with the vertebral and axillary borders of the scapula.

Processes from it cover the deeper surface of the deltoid, and form sheaths to all the muscles of this group.

1. DELTOID

The **deltoid muscle** (figs. 262 and 264)—named from its resemblance to the Greek letter *delta* when inverted—is a very thick triangular sheet, with the apex directed downwards, and with its plane curved upon itself from before backwards, so as to wrap round the front, outer side, and back of the upper end of the humerus.

Origin.—(1) The anterior border and adjacent part of the upper surface of the outer third of the clavicle; (2) the outer border and adjacent part of the upper surface of the acromion; (3) the lower border of the spine of the scapula and the fascia covering the infra-spinatus muscle, near the vertebral border of the scapula.

Insertion.—A rough triangular impression, with the apex downwards, and from two to three inches long, just above the middle of the outer surface of the humerus.

Structure.—At the front and back part of its origin it arises by short, tendinous fibres which end in parallel muscular bundles. At the middle part, strong fibrous septa three or four in number pass downwards from the acromion process into the substance of the muscle, upon the surface of which their outer edges are visible. The fleshy fibres of this part of the muscle arise both from the acromion and from the surfaces of these septa. The short strong tendon of insertion is prolonged upwards into three fibrous planes, which, as well as the tendon, receive the fleshy fibres of the middle part in multipenniform fashion. The muscular bundles from the front and back parts of the origin are inserted upon the anterior and posterior surfaces of the tendon of insertion. In front, this tendon is connected with that of the pectoralis major; below, it gives fibres to the external intermuscular septum, and also to the upper part of the brachialis anticus.

Nerve-supply.—From the posterior cord of the brachial plexus (through the fifth and sixth cervical nerves) by means of the circumflex nerve. This nerve enters the deep surface of the muscle by several filaments about half way between the origin and insertion.

Action.—When all its fibres contract together, it will abduct the humerus through a right angle. If the first and second parts act alone, they will flex and abduct the arm, as when it is raised to the level of the shoulder and at the same time directed forwards. The posterior and middle portions of the muscle by their contraction will abduct the arm, and at the same time extend it, as when the arm is elevated, and at the same time directed backwards.

The movements of abduction, or of abduction combined with flexion, are through 90°; of abduction combined with extension, only through 45°. In its action the muscle forms a lever of the third order. The greater advantage which it gains by its insertion at a considerable distance from its fulcrum at the shoulder-joint is lost by the extreme obliquity of its direction. Hence the great thickness and strength of the muscle, and the facility with which this movement is lost by injury or disease. For the proper action of this muscle in elevation of the arm, it is necessary that the scapula should be held firm by means of the serratus magnus.

Relations.—Superficially, the integument and deep fascia; upon its front border, the pectoralis major, a small artery, and the cephalic vein; deeply, the coracoid process and upper extremity of the humerus, the tendons of the pectoralis minor and major, the short head of the biceps, coraco-brachialis, subscapularis, supra-spinatus, infra-spinatus, teres minor, the long heads of the biceps and triceps, the outer head of the triceps, the coraco-clavicular and coraco-acromial ligaments, the circumflex arteries and nerve, and a large bursa which separates the muscle from the greater tuberosity of the humerus and the structures attached to it; below, it comes into contact with the upper part of the brachialis anticus.

Variations.—The clavicular portion of its origin may reach inwards as far as that of the pectoralis major, and the two muscles may blend along their adjacent borders. Behind, it may receive separate bands from the fascia infra-spinata or the borders of the scapula. Occasionally transverse fibres have been found lying in the substance of the muscle close to its acromial origin.

2. SUPRA-SPINATUS

The **supra-spinatus**—named from its position above the spine of the scapula—is a somewhat fan-shaped, thick triangular sheet.

Origin.—(1) The inner two-thirds of the supraspinous fossa; (2) the upper surface of the spine of the scapula; and (3) the fascia covering the muscle.

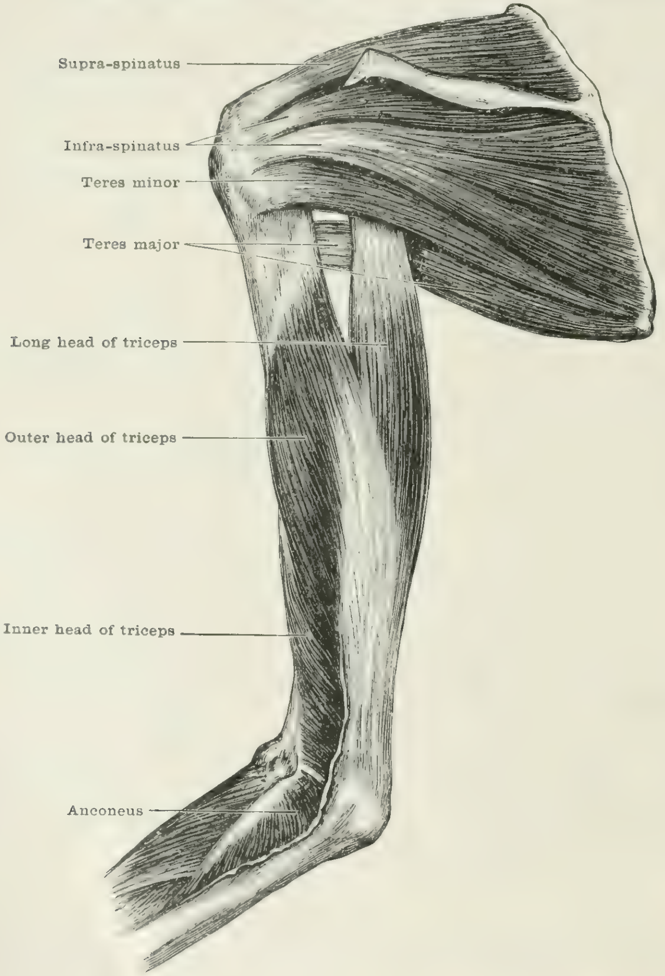
Insertion.—(1) The upper facet of the greater tuberosity of the humerus; and (2) the capsular ligament of the shoulder-joint.

Structure.—It arises by fleshy fibres which converge upon a tendon which is concealed in the substance of the muscle almost to the point of its insertion.

Nerve-supply.—From the brachial plexus (through the fifth cervical nerve) by the suprascapular branch which enters the muscle upon its deep aspect near its upper border.

Action.—It assists the deltoid in abducting the arm; it also strengthens the shoulder-joint by resisting the tendency to upward displacement of the head of the humerus, and by drawing the head of the humerus firmly towards the centre of the glenoid cavity.

FIG. 268.—BACK VIEW OF THE SCAPULAR MUSCLES AND TRICEPS.


Supra-spinatus
Infra-spinatus
Teres minor
Teres major
Long head of triceps
Outer head of triceps
Inner head of triceps
Anconeus

Relations.—Superficially, the trapezius, deltoid, and coraco-acromial ligament; deeply, the omo-hyoid muscle and capsular ligament, the suprascapular vessels and nerve.

3. INFRA-SPINATUS

The **infra-spinatus**—named from its position below the spine of the scapula—is a thick, fan-shaped sheet.

Origin.—(1) The inner two-thirds of the infraspinous fossa; (2) the under surface of the spine of the scapula; (3) the infraspinous fascia, and a thick intermuscular septum which separates it from the teres minor and major muscles.

Insertion.—(1) The middle facet on the greater tuberosity of the humerus; and (2) the capsule of the shoulder-joint.

Structure.—Its origin is by fleshy fibres which converge outwards in bipenniform fashion upon the tendon. Frequently that part which arises from the lower surface of the spine of the scapula overlies and is somewhat separate from the rest. Its insertion into the capsule and tuberosity is by a tendon which is almost entirely concealed by fleshy fibres.

Nerve-supply.—From the brachial plexus (through the fifth cervical nerve), by the suprascapular branch which enters the deep surface of the muscle at its outer part and near its upper border.

Action.—It is the chief external rotator of the humerus. This movement of external rotation is through about 90°, and is of great importance. When the elbow is bent, it produces the lateral movement of the hand by which, in writing, the pen is carried from left to right across the page. When the elbow is extended, the rotation of the humerus adds considerably to the range of rotatory movement enjoyed by the hand. The infra-spinatus also adducts the elevated arm, at the same time drawing it slightly backwards, or extending it. It helps to hold the head of the humerus in contact with the glenoid cavity.

Relations.—Superficially, the infraspinous fascia which separates it from the deltoid, trapezius, and latissimus dorsi; deeply, the suprascapular and dorsalis scapulæ vessels, and sometimes a small bursa which intervenes between its tendon and the capsule of the shoulder-joint; externally, the teres major and minor.

Variations.—The slip from the under surface of the spine is frequently almost as separate from the infra-spinatus as the teres minor, and sometimes there is no separation between the infra-spinatus and teres minor.

4. TERES MINOR

The **teres minor**—named from its being the lesser of two somewhat cylindrical muscles (*teres* = round or cylindrical)—is a thick but narrow triangular or fan-shaped sheet.

Origin.—(1) The impression which occupies the upper two-thirds of the axillary border of the infraspinous fossa; (2) septa which separate it from the infra-spinatus behind, and the teres major in front.

Insertion.—(1) The lowest of the three facets on the greater tuberosity of the humerus and the posterior surface of that bone for one inch (2·5 cm.) below the facet; (2) the capsule of the shoulder-joint.

Structure.—From a fleshy origin which terminates in a point below, its fibres pass upwards and outwards to their insertion, which is by a short strong tendon into the lowest facet on the tuberosity, and the capsule of the shoulder-joint; below the facet it is inserted by fleshy or very short tendinous fibres.

Nerve-supply.—From the posterior cord of the brachial plexus (through the fifth cervical nerve) by the lower division of the circumflex nerve which enters the muscle upon its anterior surface near its insertion. The nerve is remarkable on account of the ganglion upon its trunk shortly before it passes into the muscle.

Action.—The same as that of the preceding muscle, of which it may be considered to form a part. It will therefore rotate the arm outwards and at the same time adduct.

Relations.—Behind, the deltoid; in front, the long head of the triceps, the teres major, and subscapularis. Above and internally, the dorsalis scapulæ vessels run between it and the axillary border of the scapula.

5. SUBSCAPULARIS

The **subscapularis muscle**—named from its position beneath the scapula—is a thick triangular and somewhat multipenniform sheet.

Origin.—(1) The whole of the ventral surface of the scapula with the exception of the part near the neck, and the spaces at the upper and lower angles occupied by the serratus magnus; (2) the lower two-thirds of the grooved outer border of the scapula; and (3) the intermuscular septum between it and the teres major.

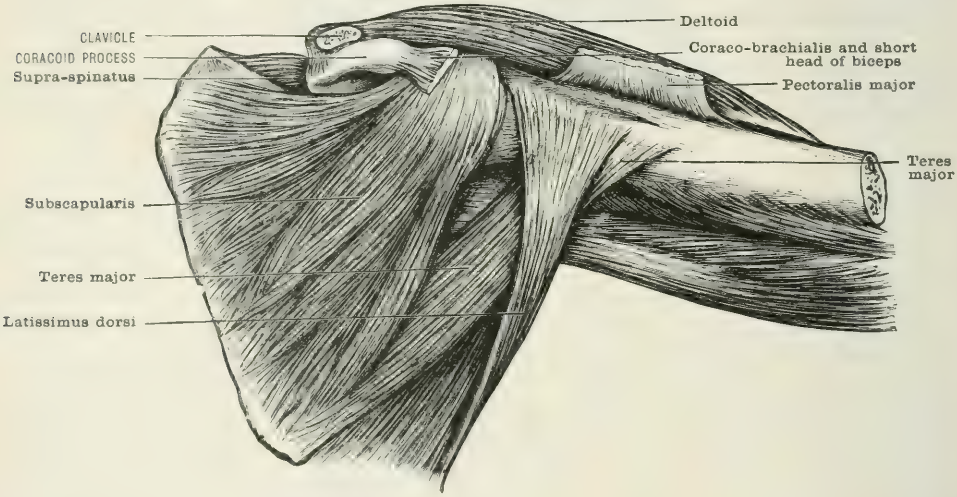
Insertion.—(1) The lesser tuberosity of the humerus, and the part of the shaft immediately below it; (2) the front of the capsular ligament of the shoulder-joint.

Structure.—Its origin is by fleshy fibres from the surface of the bone, and also by bipenniform bundles from the upper and lower surfaces of three or four septa which are attached to the transverse ridges upon the venter scapulæ, so that the whole muscle has a multipenniform arrangement. The fibres converge upwards and outwards upon a strong tendon which is hidden by fleshy fibres to within a short distance of its insertion, the lower part of which is also fleshy. A bursa intervenes between the tendon and the base of the coracoid process, and is usually in connection with the shoulder-joint.

Nerve-supply.—From the posterior cord of the brachial plexus (through the fifth and sixth cervical nerves), by the short and part of the lower subscapular nerves. They enter the front surface of the muscle, the former near its upper, the latter near its outer border.

Action.—It is the chief internal rotator of the humerus; at the same time it adducts it after it has been elevated. It also has an important influence in strengthening the shoulder-joint by drawing the head of the humerus towards the glenoid cavity.

Fig. 269.—Front View of the Scapular Muscles.



Relations.—Its anterior and internal face forms the greater part of the posterior wall of the axilla, and is in contact with the serratus magnus, the short head of the biceps, and the coraco-brachialis, the axillary vessels with many of their branches, the brachial plexus and its branches, the lymphatic glands and vessels; its outer border lies in contact with the teres major, the posterior circumflex and dorsalis scapulæ vessels, and the circumflex nerve; behind lie the long head of the triceps and the teres minor muscle, and the bursa which intervenes between its tendon and the capsule of the shoulder-joint.

Variations.—Occasionally a separate slip arises from the axillary border of the scapula, and is inserted into the capsule of the shoulder-joint or into the humerus.

6. TERES MAJOR

The **teres major**—named from its somewhat cylindrical shape and its size—is a thick ribbon-shaped muscle.

Origin.—(1) The oval facet which occupies the lower third of the axillary border of the infraspinous fossa; (2) the infraspinous fascia and the intermuscular septa, which separate the muscle from the subscapularis, the teres minor, and infraspinatus.

Insertion.—The inner lip of the bicipital groove from the lower border of the lesser tuberosity for about two inches (5 cm.) down the humerus.

Structure.—Its origin is by fleshy fibres which pass upwards, outwards, and somewhat forwards, to be inserted by a strong tendon, which is first visible upon the outer border, and then upon the anterior surface of the muscle, and which is in close relation with the back of the tendon of the latissimus dorsi. A small bursa intervenes between the two tendons.

Nerve-supply.—From the posterior cord of the brachial plexus (through the sixth and seventh cervical nerves) by the lower subscapular nerve, which enters the muscle upon its anterior aspect close to the middle of its inner border.

Action.—It assists the latissimus dorsi as a strong adductor, and in some positions of the arm as an internal rotator of the humerus.

When the arm is fixed it will act with the latissimus dorsi in drawing the body upwards, as in climbing. Its influence, however, will be exerted upon the lower angle of the scapula, while that of the latissimus dorsi is chiefly upon the trunk and pelvis.

Relations.—In front lie the latissimus dorsi, both heads of the biceps, the coraco-brachialis, the pectoralis major, the axillary vessels, and the lower branches of the brachial plexus; behind, the latissimus dorsi, teres minor, the long and outer heads of the triceps; between its upper border and the subscapularis muscle are the posterior circumflex and dorsalis scapulæ vessels, and the circumflex nerve; below are the superior profunda vessels and the musculo-spiral nerve.

7. CORACO-BRACHIALIS

The **coraco-brachialis**—named from its attachment to the coracoid process and the upper arm (*brachium*)—is a cylindrical muscle, but somewhat fusiform at the extremities.

Origin.—(1) The tip of the coracoid process; (2) the inner side of the tendon of the short head of the biceps.

Insertion.—(1) The rough impression two or three inches long upon the inner border of the humerus in its middle third, and in front of the internal intermuscular septum (see page 306); (2) the internal intermuscular septum and an aponeurotic band which extends upwards from the septum in front of the tendons of the teres major and the latissimus dorsi to the lesser tuberosity of the humerus.

Structure.—It arises from the coracoid process by a short tendon, which is blended upon its inner side with the insertion of the pectoralis minor, and from the short head of the biceps by fleshy fibres for three or four inches (8–10 cm.) below the coracoid process. From this origin the fibres run parallel to one another, and are inserted by a short tendon. The muscle is frequently divided into two planes between which the external cutaneous nerve passes.

Nerve-supply.—From the outer cord of the brachial plexus (through the seventh cervical nerve) by the musculo-cutaneous branch, which either pierces it about the middle upon its way to the biceps and brachialis anticus, or sends a branch to it in this position, while the rest of the nerve passes in front of the muscle.

Action.—To adduct and flex the humerus. As it lies at so small an angle with the axis of that bone, it assists materially in pressing the head of the humerus against the glenoid cavity, and so helps to prevent dislocation.

Relations.—Superficially, the deltoid and pectoralis major; deeply, the subscapularis, latissimus dorsi, teres major, and triceps. Upon its outer side lies the short head of the biceps; upon its inner side the pectoralis minor, the axillary and brachial vessels, with the median nerve and other branches of the brachial plexus.

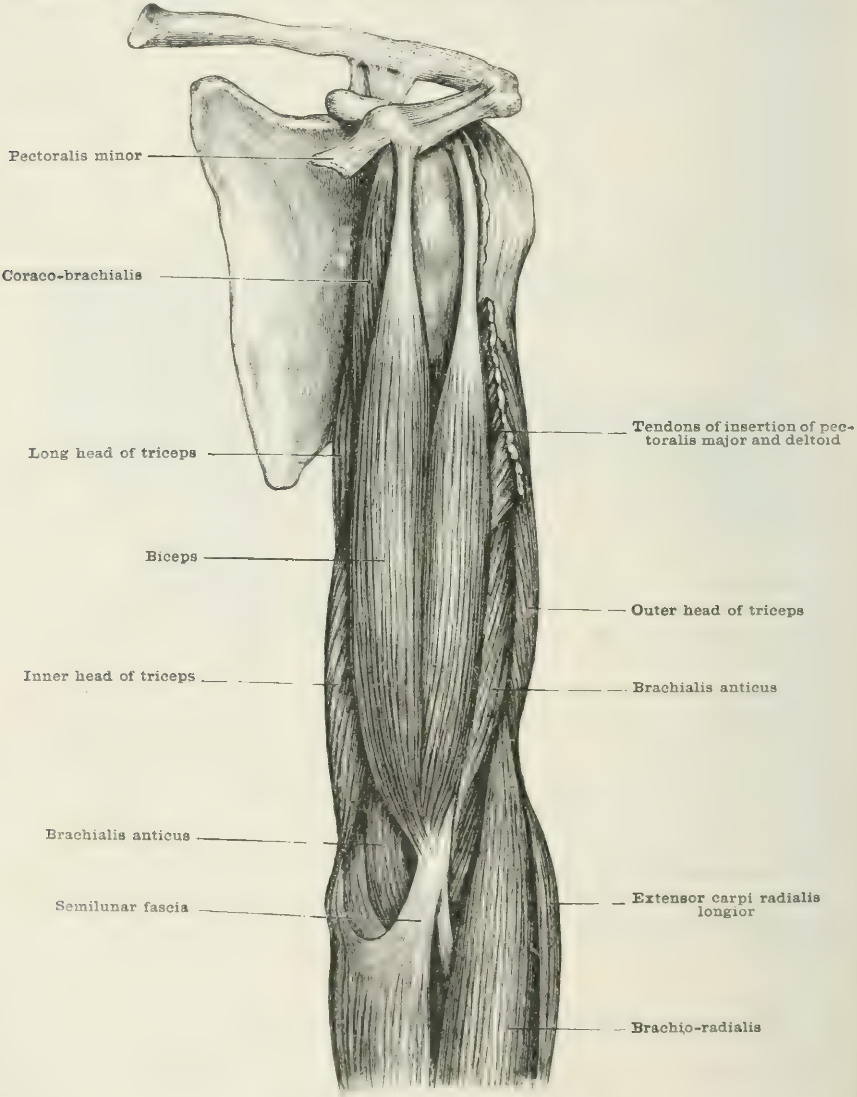
Variations.—The coraco-brachialis varies chiefly in its insertion, which may extend as high as the capsule of the shoulder or the lesser tuberosity, occasionally forming in this position a separate muscle (the rotator humeri); or it may descend as low as the inner condyle. It sometimes sends a slip to the triceps or brachialis anticus.

GROUP OF MUSCLES WHICH MOVE THE ELBOW-JOINT

Fascia of the Upper Arm

The **deep fascia** of the upper arm forms a strong tube, thicker upon the posterior than the anterior aspect, enclosing all the muscles and most of the vessels and nerves. Above, it is continuous on the outer side and front with the fascia covering the deltoid and pectoralis major, and internally with the axillary fascia. In the lower two-thirds of the upper arm it is joined upon its deep aspect by two strong processes: the *external intermuscular septum*, which arises from the external condylar ridge and the outer border of the humerus; and the *internal intermuscular septum*, which arises from the internal condylar ridge and the inner border of the humerus. The tube formed by the deep fascia is thus divided by the bone and these two septa into two compartments. In the front compartment are placed the flexors of the elbow-joint, and in the back compartment the great extensor muscle.

Fig. 270.—Superficial View of the Front of the Upper Arm.


Pectoralis minor
Coraco-brachialis
Tendons of insertion of pectoralis major and deltoid
Long head of triceps
Biceps
Outer head of triceps
Inner head of triceps
Brachialis anticus
Brachialis anticus
Semilunar fascia
Extensor carpi radialis longior
Brachio-radialis

FLEXORS OF THE FOREARM

The flexor muscles are three in number. The most superficial is the biceps, which arises from the scapula; while more deeply lie the brachialis anticus and brachio-radialis (supinator longus), which arise from the humerus.

1. BICEPS

The **biceps flexor cubiti**—named from its two heads and its action upon the cubitus, or elbow—is a thick, somewhat flattened fusiform muscle with a bifid upper extremity.

Origin.—(1) The **short head** from the outer side of the tip of the coracoid process, in close connection with the coraco-brachialis muscle; (2) the **long head,** from the upper border of the glenoid fossa of the scapula and from the glenoid ligament.

Insertion.—(1) The posterior border of the tubercle of the radius; (2) the upper part of the deep fascia on the inner side of the front of the forearm, two inches (5 cm.) below the inner condyle of the humerus.

Structure.—The short head arises by a short tendon from which the fleshy fibres diverge in a somewhat conical form until they meet and blend with the outer and longer head about the middle of the upper arm.

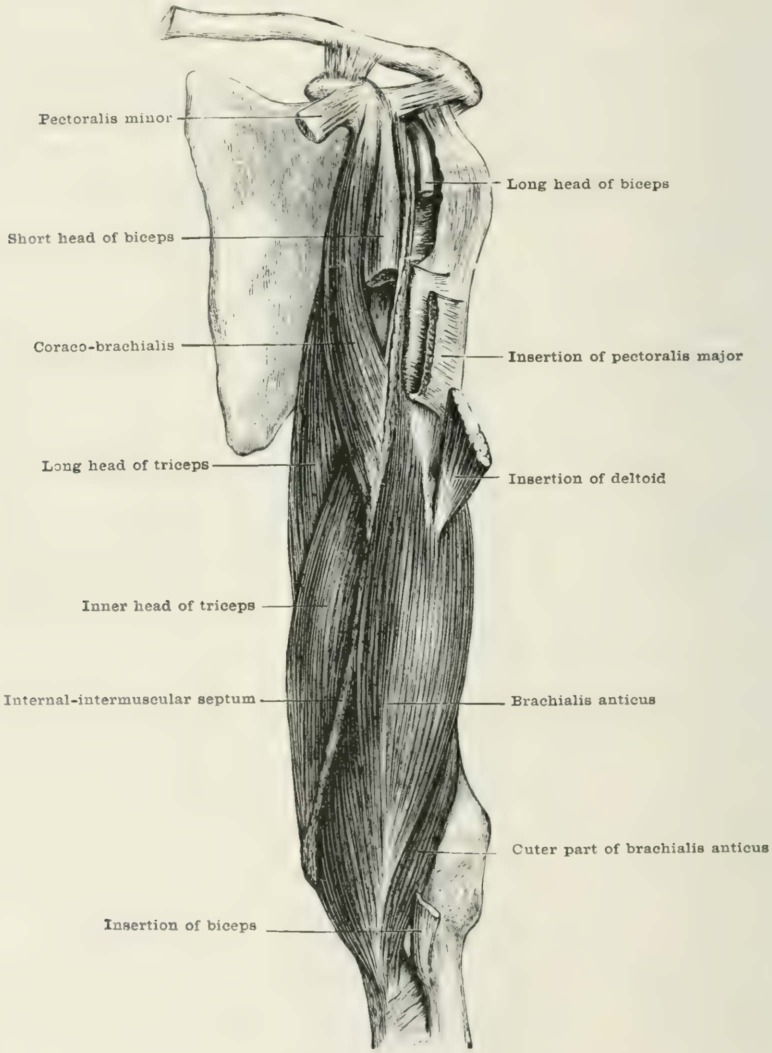
The long head arises by a thick ribbon-like tendon three to four inches (about 9 cm.) long, which at its origin upon the upper border of the glenoid fossa bifurcates and blends with the glenoid ligament of the shoulder-joint. It first passes outwards and arches over the rounded head of the humerus. It afterwards enters the canal formed by the bicipital groove internally, and externally by the capsule of the joint, together with the aponeurotic expansion derived from the tendon of the pectoralis major. Down to this point it is invested by synovial membrane, which is reflected upon it from the adjacent bone and capsule. After emerging at the lower end of the bicipital groove it gives origin to a conical mass of fleshy fibres, which meet with the fibres derived from the shorter head about the middle of the upper arm. The fleshy bundles belonging to the two heads may be separated for a considerable distance by careful dissection. A little below the middle of the upper arm, the tendon of insertion commences as a septum between the two bellies of the muscle. It rapidly increases in thickness, and about the level of the condyles it becomes free, and as a flattened cord passes down in the middle of the bend of the elbow and turns upon itself so that its anterior aspect now becomes external; before its insertion into the posterior border of the tubercle of the radius it is separated from that process by a small synovial bursa. About an inch and a half (4 cm.) from its insertion it gives off from its inner border a strong band of fibrous tissue three-quarters of an inch broad and one inch long (the semilunar fascia), to the deep fascia covering the ulnar surface of the forearm.

Nerve-supply.—From the outer cord of the brachial plexus (through the sixth and seventh cervical nerves) by a branch of the musculo-cutaneous nerve which enters the muscle on its posterior aspect near its inner border.

Action.—(1) It flexes the elbow-joint by means of its radial insertion, and also by the attachment of the semilunar fascia to the inner side of the forearm. (2) It supinates strongly the forearm by means of the radial tendon which wraps round the tubercle of the radius. This movement will be most powerful when the elbow is bent to a right angle, as the tendon is then perpendicular to the bone, which it causes to revolve. To increase its leverage, the tendon is lifted away from the axis of the bone by the prominence of the tubercle. (3) It will assist somewhat feebly in the movements of the shoulder-joint, its short head being, like the coraco-brachialis, a flexor and adductor of the upper arm. By its long head it binds down the upper portion of the humerus, and prevents the tendency to dislocation upwards. When the forearm is fixed, the biceps will help in flexing the elbow, as in climbing or in drawing up the trunk to a horizontal bar.

Relations.—Superficially, the deltoid and pectoralis major, the deep fascia, and at the bend of the elbow the median cephalic vein and brachio-radialis; deeply, the humerus, the brachialis anticus, and supinator brevis; upon its inner side lie the coraco-brachialis, the brachial vessels, and the median nerve. The semilunar fascia separates the median basilic vein from the brachial vessels and median nerve.

FIG. 271.—DEEP VIEW OF THE FRONT OF THE UPPER ARM.


Pectoralis minor
Long head of biceps
Short head of biceps
Coraco-brachialis
Insertion of pectoralis major
Long head of triceps
Insertion of deltoid
Inner head of triceps
Internal-intermuscular septum
Brachialis anticus
Outer part of brachialis anticus
Insertion of biceps

Variations.—The origin of the biceps is remarkably variable. Sometimes one of the heads is deficient. More often a third head is derived from the middle of the inner border of the humerus, and sometimes as many as three additional heads have been found arising from the humerus. Occasionally it sends slips to the internal intermuscular septum, internal condyle, or coronoid process.

2. BRACHIALIS ANTICUS

The **brachialis anticus**—named from its intimate relation with the front of the humerus (*brachium*)—is a thick, somewhat fusiform sheet, curved from side to side to fit on to the front of the humerus, and slightly bifid above.

Origin.—The whole of the lower three-fifths of the front of the humerus, with the exception of the small space on its inner aspect occupied by the coraco-brachialis and the impression upon the outer aspect for the deltoid muscle, upon either side of which it sends up two small pointed processes; (2) the front of the internal intermuscular septum; (3) a small portion of the upper part of the front of the external intermuscular septum above the point where it is pierced by the musculo-spiral nerve.

Insertion.—The inner and lower part of the rough triangular impression upon the front of the coronoid process of the ulna.

Structure.—The greater part of its origin is by fleshy fibres which converge upon a tendinous sheet which makes its appearance at first upon the anterior surface of the muscle, just above the level of the elbow-joint. This tendinous sheet receives the converging fleshy fibres upon its posterior aspect, and becomes gradually thicker until it forms a very strong tendon of insertion which is closely connected with the front of the anterior ligament of the elbow-joint. The lower and outer portion of the muscle is deeply grooved by the brachio-radialis (supinator longus), so that it often looks like a separate muscle.

Nerve-supply.—(1) From the external cord of the brachial plexus (through the sixth cervical nerve) by branches of the musculo-cutaneous nerve which enter the anterior surface of the muscle near the inner border of its upper third; (2) from the posterior cord of the brachial plexus (through the seventh cervical nerve) by a small filament from the musculo-spiral nerve which enters the front of that part of the muscle which is concealed by the origin of the brachio-radialis (supinator longus).

Action.—To flex the ulna. Like the biceps, it will form a lever of the third order, but with much mechanical disadvantage on account of the proximity of its insertion to the axis of the elbow-joint. There will be, however, a proportional gain in speed and range of movement.

Relations.—In front, the deep fascia on the outer side of the arm which separates it from the cephalic vein, the biceps, coraco-brachialis, deltoid, brachio-radialis (supinator longus), and extensor carpi radialis longior, the brachial vessels, median and musculo-spiral nerves; behind, the triceps and elbow-joint.

Variations.—The brachialis anticus is sometimes divided into two heads by a continuation of the cleft between the two pointed processes above mentioned, or by a separation of a part of the outer half. Occasionally it gives off muscular slips to the radius or the fascia of the forearm, also to adjacent muscles such as the pronator teres, the brachio-radialis, and the extensor carpi radialis longior.

3. BRACHIO-RADIALIS

The brachio-radialis (supinator longus) is described with the radial group of muscles (page 321).

EXTENSORS OF THE FOREARM

The extensor muscles are two in number—the triceps and the anconeus.

1. TRICEPS

The **triceps extensor cubiti**—named from its three heads and its action upon the elbow or cubitus—forms a thick fusiform sheet wrapping round the posterior surface of the humerus in its whole length.

Origin.—The **long head** arises from the lower edge of the glenoid cavity and the axillary border of the scapula for one inch (2·5 cm.) below it.

The **external head** arises (1) from the posterior surface of the humerus above the musculo-spiral groove, reaching as far up as the base of the greater tuberosity and the insertion of the teres minor; (2) from the back of the external intermuscular septum above the point where it is pierced by the musculo-spiral nerve.

The **internal head** arises (1) from the whole of the posterior surface of the humerus between the musculo-spiral groove and the olecranon fossa; (2) on the inner side, from the back of the whole of the internal intermuscular septum; (3) on the outer side, from the back of that portion of the external intermuscular septum which lies below the point where it is pierced by the musculo-spiral nerve.

Insertion.—(1) The posterior part of the upper surface of the olecranon process; and (2) on either side by aponeuroses which are continuous with the deep fascia on the back of the forearm.

Structure.—The long head forms a strong fusiform muscular band, arising by tendinous fibres which blend with the lower part of the capsule of the shoulder-joint. The surfaces of the band at first look inwards and outwards. The tendon of origin extends for some distance further on the inner than on the outer surface. As the muscular band passes downwards, it twists upon itself so that what was the internal surface now becomes posterior, and the external surface becoming the anterior is applied to the back of the rest of the muscle. Upon this anterior surface the common tendon of insertion begins as a broad aponeurosis about three inches (8 cm.) from the scapula, and receives the fleshy fibres of the long head in penniform fashion chiefly upon its upper border and posterior surface. These fleshy fibres are continued as a thick band along the inner border of this common tendon, and terminate in a blunt point a little below the junction of the middle and lower thirds of the arm.

The external head arises by fleshy fibres which are inserted in penniform fashion into the outer border of the common aponeurosis. The lowest of these fibres arise from a tendinous arch which bridges over the musculo-spiral nerve.

The internal head, which is much stronger than the outer, forms a thick triangular sheet, wrapping round the back of the bone, and arising also from the back of the intermuscular septa on either side. The apex of this triangle extends upwards along the lower border of the musculo-spiral groove to a point just below the insertion of the teres major. Its fleshy fibres pass downwards and somewhat backwards to the broad aponeurosis, which, after receiving the fleshy fibres from the outer and long heads, completely covers the whole of the posterior surface of the muscle in the lower third of the arm. A few fleshy fibres of this head are inserted directly into the olecranon and the adjacent posterior ligament; the slip attached to the ligament is sometimes called the **subanconeus.**

The insertion of the tendon into the back part of the upper surface of the olecranon is usually separated from the adjacent part of the olecranon and the posterior ligament of the elbow-joint by a small bursa. That part of the aponeurotic continuation of the tendon which lies between the olecranon process and the back of the external condyle is by far the stronger.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh and eighth cervical nerves) by means of the musculo-spiral, which supplies branches to the long and inner heads in the first part of its course; and numerous other branches to the inner and outer heads while passing through the musculo-spiral groove.

Action.—To extend the elbow-joint, the muscle acting as a lever of the first order, at a very great mechanical disadvantage on account of the short distance which intervenes between the olecranon process and the axis of the elbow-joint; but at the same time with a great gain in speed and range of movement. Hence this muscle is the chief agent in movements of the arm in which great speed is attained, such as in throwing a stone or striking a blow. The long head has some influence as an adductor of the shoulder-joint; it has also a supplementary ligamentous action upon that joint similar to that of the coraco-brachialis by holding the head of the humerus in close contact with the glenoid cavity. As it passes over both the shoulder- and the elbow-joints, the long head enables the powerful abductors of the shoulder to exert a peculiar influence upon the extension of the elbow joint. If it were merely a passive ligament, the long head would extend the elbow whenever the humerus was abducted by the deltoid muscle. As, however, the long head contracts at the same time with the deltoid, we have an apparatus by which, so to speak, a double rapidity of extension is secured for the elbow-joint. This attachment, therefore, of the long head of the triceps to the scapula is the chief cause of the rapid movements of the lower end of the forearm which are made use of in throwing and striking.

Acting from below, the triceps will extend the upper arm upon the forearm, as in the use of the parallel bars, and in many other gymnastic exercises.

Relations.—The long head lies behind the subscapularis, teres major, and latissimus dorsi, in front of the teres minor, with the dorsalis scapulæ vessels upon its posterior, and the posterior circumflex vessels and the circumflex nerve upon its anterior border. Lower down, the posterior surface of the muscle is only separated from the integuments by the deep fascia; in front lie the brachialis anticus, brachioradialis (supinator longus), extensor carpi radialis longior, and coraco-brachialis, with the superior and inferior profunda vessels and the ulnar and musculo-spiral nerves. A small bursa intervenes between the tendon and part of the olecranon process. The muscle is also in relation with the shoulder- and elbow-joints.

Variations.—The internal head sometimes arises as high as the greater tuberosity. An additional slip is occasionally received from the capsule of the shoulder-joint, the coracoid process, or the tendon of the latissimus dorsi. A slip of muscle is frequently separated from the lower border of the internal head, and, passing from the inner condyle to the olecranon, bridges over the ulnar nerve.

2. ANCONEUS

The anconeus is described with the Muscles on the Back of the Forearm (page 327).

MUSCLES OF THE FOREARM

The muscles of the forearm are enveloped by a strong **deep fascia** which is continuous with that of the upper arm. It is thickest upon the posterior aspect, where it is attached to the sides of the triangular posterior surface of the olecranon, and to the whole of the posterior ridge of the ulna. Below the internal condyle it receives the broad band of the bicipital fascia; and behind, the aponeurotic insertion of the triceps. In the bend of the elbow it is pierced by a communicating vein. On the outer side and back of the forearm the deep fascia has numerous connections with the longitudinal ridges on the lower ends of the radius and ulna. It also becomes much thickened by the addition of transverse bands, so as to form the **posterior annular ligament,** which passes from the outer border of the lower end of the radius, inwards and at the same time a little downwards, to the ulnar border of the carpus, where it is attached to the inner sides of the pisiform and cuneiform bones. On its anterior surface this ligament is attached to the ridges upon the back of the lower extremity of the radius, and so forms canals through which pass the tendons of the long muscles upon the radial border and posterior surface of the forearm. The ligament is also in contact with the lower end of the ulna, which it binds in its place, much in the same manner as the head of the radius is held in position by means of the orbicular ligament, but it has no insertion into this bone.

In the front of the wrist the deep fascia forms a thin layer, which overlies the **anterior annular ligament.** The latter is sometimes described as a thickening of the same fascia, but really it is continuous with a thin aponeurosis which separates the first and second layers of the muscles of the forearm shortly to be described. It is a strong band of fibrous tissue, which stretches transversely from the pisiform bone and unciform process on the ulnar side of the carpus to the scaphoid and the trapezium on the radial side.

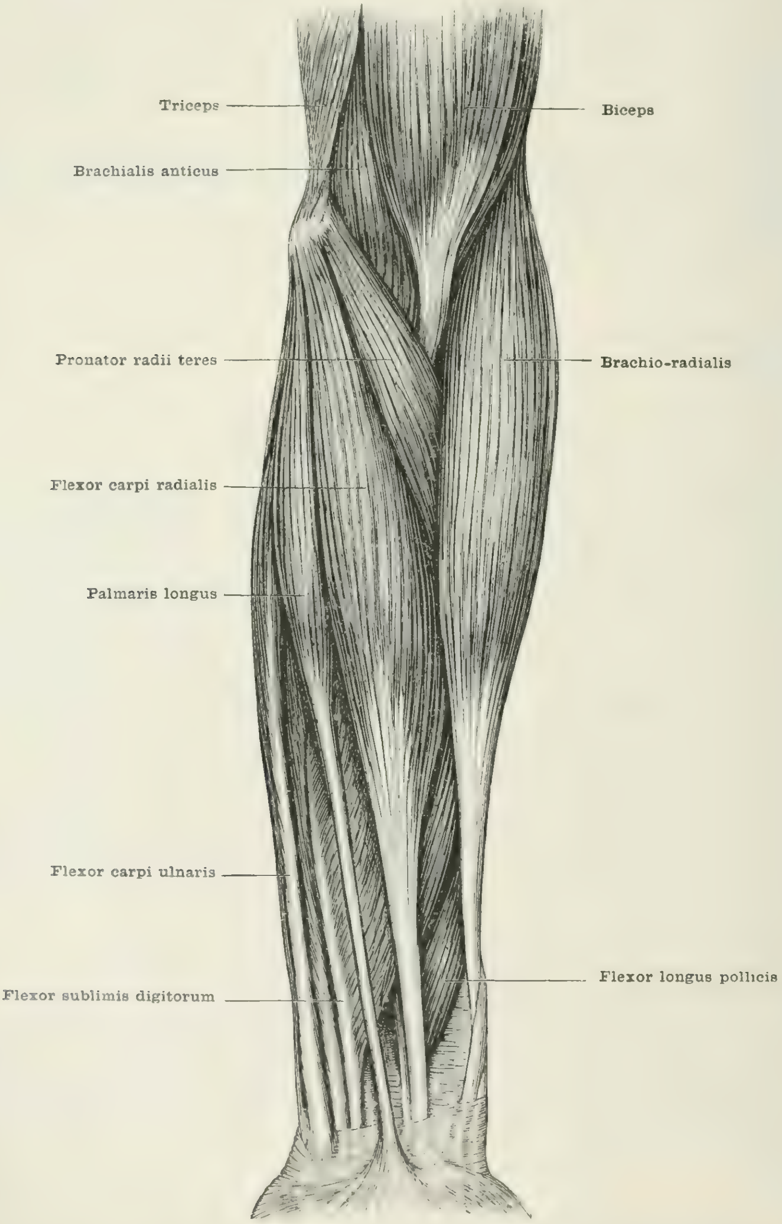
MUSCLES OF THE FRONT OF THE FOREARM

The muscles upon the front of the forearm form four planes or layers: the first two layers having their origins from the front of the internal condyle; the last two from the bones of the forearm alone.

FIRST LAYER

The first layer consists of four muscles—the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris—which all arise by a common tendon from the front of the internal condyle, and by separate attachments from the deep fascia of the forearm and the intermuscular septa; while the innermost and outermost have additional origins from the ulna.

FIG. 272.—FRONT OF THE FOREARM: FIRST LAYER OF MUSCLES.


Triceps
Biceps
Brachialis anticus
Pronator radii teres
Brachio-radialis
Flexor carpi radialis
Palmaris longus
Flexor carpi ulnaris
Flexor longus pollicis
Flexor sublimis digitorum

1. PRONATOR RADII TERES

The **pronator radii teres**—named from its action and somewhat cylindrical shape—is a thick ribbon-shaped muscle.

Origin.—First head: (1) by the common tendon from the front of the internal condyle; and (2) from the lowest part of the internal condylar ridge; (3) from the deep fascia covering it, and the intermuscular septum which separates it from the flexor carpi radialis and the flexor sublimis digitorum.

Second head: from the inner border of the coronoid process.

Insertion.—The rough impression on the middle of the outer surface of the radius.

Structure.—The higher of the two heads, which is much the larger, arises partly by a short tendon, and partly by muscular fibres, and is separated from the lower head by a small tendinous arch through which passes the median nerve. The lower head, which lies concealed by the rest of the muscle, arises by a small aponeurotic band. The thick fleshy muscle passes obliquely downwards and outwards across the front of the forearm. Below the middle of its anterior surface begins the tendon of insertion, which expands and covers the whole of the muscle for a short distance before it is inserted by a strong fibrous band into the special impression for it upon the most prominent portion of the outward curve of the radius.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the sixth cervical nerve) by means of filaments derived from the median nerve just before it passes through the arch between the two heads. These filaments enter the muscle at its deep surface a short distance above the middle of its outer border.

Action.—(1) To pronate the forearm. In supination, the tendon is to some extent wrapped round the radius, as the tendon of the biceps is in pronation. In contraction, the muscle so to speak, unwraps itself and so causes the radius to revolve around the axis, which passes through the middle of its head and the lower end of the ulna. Its insertion into the convexity of the curve of the radius places the line of the muscle as far as possible from this axis, and so gives it some mechanical advantage. On the other hand, the obliquity of its insertion diminishes the power of the muscle, and is one of the causes which make pronation a more feeble movement than supination. (2) It will also assist in the flexion of the forearm.

Relations.—Superficially, the bicipital and deep fasciæ and superficial veins, the radial vessels and nerve, and, lower down, the brachio-radialis (supinator longus) and radial extensors. Deeply, the brachialis anticus, flexor sublimis digitorum, supinator brevis, and the median nerve. By its outer border, it forms the inner boundary of the space at the bend of the elbow, and by its inner border it is in contact with the flexor carpi radialis.

Variations.—The pronator radii teres frequently extends at its origin for some distance further up the internal condylar ridge. It may also receive a separate head from the internal intermuscular septum, the inner border of the humerus, or an abnormal supracondylar process; sometimes also from the biceps or brachialis anticus. This third head bridges over the brachial artery and median nerve.

2. FLEXOR CARPI RADIALIS

The **flexor carpi radialis**—named from its action as a flexor of the wrist and its position on the radial side of the joint—is flat and fusiform.

Origin.—(1) The common tendon from the front of the internal condyle; (2) the deep fascia and the intermuscular septa which lie between the muscle and the pronator radii teres, the flexor sublimis digitorum, and the palmaris longus.

Insertion.—The front of the base of the second metacarpal bone; and usually by a smaller slip into that of the third as well.

Structure.—Its fleshy fibres are contained in an aponeurotic case which forms an elongated four-sided pyramid, the apex being at the internal condyle, and the sides consisting of the deep fascia and the intermuscular septa which intervene between it and the adjacent muscles. The fleshy fibres converge downwards and somewhat outwards upon the back of the tendon which begins at the junction of the upper and middle thirds of the forearm, and is free a little below the middle of the forearm.

At the wrist the tendon passes through a special compartment external to the tube formed by the anterior annular ligament. This compartment is bounded behind by the scaphoid bone and the groove upon the trapezium; externally, by the tuberosity of the scaphoid bone and the ridge upon the trapezium; and in front and internally by a thickening of the deep fascia of the forearm. It is lined by a special synovial membrane.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the sixth cervical nerve) by filaments from the median nerve which pass to its posterior surface in its upper third.

Action.—(1) To flex the wrist. By its insertion into the metacarpus it bends not only the radio-carpal joint (which is the wrist-joint proper), but also the intercarpal and the carpo-metacarpal joints, which really take part in all the movements of what may be called the *wrist* as distinguished from the *wrist-joint*. (2) When the hand is fully supinated, it helps in pronation. (3) It is also a feeble flexor of the elbow.

Relations.—Superficially, the deep fascia and the superficial veins; deeply, the flexor sublimis digitorum, the flexor longus pollicis, the median nerve, the wrist and some of the carpal joints; on the outer side of it lie the pronator radii teres and the radial vessels; on the inner side it is in contact above with the palmaris longus.

Variations.—The flexor carpi radialis may have a second origin from the tendon of the biceps or the radius, and its insertion may be extended to the base of the fourth metacarpal bone or to some of the bones of the carpus. It is sometimes absent.

3. PALMARIS LONGUS

The **palmaris longus**—named from its length and its insertion upon the palm of the hand—is flat and fusiform.

Origin.—(1) The common tendon from the front of the internal condyle; (2) the deep fascia of the forearm; and (3) the septa which lie between the muscle and the flexor carpi radialis, the flexor carpi ulnaris, and the flexor sublimis digitorum.

Insertion.—(1) The upper end of the strong central portion of the palmar fascia; (2) the lower part of the front of the anterior annular ligament; and (3) the deep fascia covering the thenar eminence.

Structure.—Like the preceding muscle it consists of fleshy fibres which rise in a long four-sided pyramid from the aponeurotic case formed by the deep fascia and the intermuscular septa. Its tendon appears first upon the anterior surface of the muscle at the junction of the middle and upper thirds of the forearm, and is free about the middle of the forearm. It passes almost directly downwards to the middle of the wrist, where it descends in front of the upper part of the anterior annular ligament, and then becomes attached to its lower edge as well as the adjacent fasciæ.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the eighth cervical nerve) by filaments from the median nerve which enter the deep surface of the muscle.

Action.—(1) To flex the wrist; (2) to a slight extent to flex the elbow also; (3) it makes tense the central portion of the palmar fascia, so that when an object is grasped firmly by the fingers no injurious pressure is exerted upon the important vessels and nerves which lie beneath that structure; (4) its attachments to the fascia of the thenar eminence gives a firm origin to some of the short muscles of the thumb.

Relations.—Superficially, the deep fascia and superficial veins; deeply, the flexor sublimis digitorum and median nerve, and the upper part of the anterior annular ligament.

Variations.—The palmaris longus is very variable. It may be double, and it is often absent. The fleshy belly is sometimes below, and the tendon in part or entirely above. It may take an additional head from the radius or the coronoid process. Its insertion may be into the fascia of the forearm, the flexor carpi ulnaris, the short muscles of the little finger, or one of the carpal bones.

4. FLEXOR CARPI ULNARIS

The **flexor carpi ulnaris**—named from its influence upon the wrist and its position—is a thick sheet of muscular fibre, somewhat fusiform in shape, which wraps round the convex ulnar border of the forearm.

Origin.—First head: (1) by the common tendon from the lower part of the front of the internal condyle; (2) the deep fascia of the forearm; and (3) the septa which intervene between the muscle and the palmaris longus and flexor sublimis digitorum.

The **second head**: from the inner surface of the olecranon process, and the upper two-thirds of the posterior border of the ulna.

Insertion.—The upper surface of the pisiform bone, beyond which fibres are continued to the unciform process and the front of the base of the fifth metacarpal bone.

Structure.—The origin of the upper head is tendinous, and that of the lower is partly fleshy, partly aponeurotic; the aponeurosis from the posterior ridge of the ulna being common to it with the flexor profundus digitorum and the extensor carpi ulnaris, and being closely blended with the deep fascia of the back of the forearm. The two heads are united by a fibrous arch under which passes the ulnar nerve. From this tendinous and bony origin the fleshy fibres pass downwards and forwards in a penniform manner to be inserted into the posterior aspect of a tendon which appears on the front of the muscle a little above the middle of the forearm, and becomes free just above the wrist-joint, where it lies superficial and internal to the anterior annular ligament.

Nerve-supply.—From the inner cord of the brachial plexus (through the eighth cervical and first thoracic nerves) by filaments from the ulnar nerve which enter the deep surface of the muscle above the middle of the forearm.

Action.—(1) To flex the wrist. The pisiform bone assists this action by lifting the line of the tendon a little from the metacarpal bone, much as the patella assists the quadriceps femoris. (2) It assists somewhat feebly in adduction of the wrist. (3) It helps in the flexion of the elbow.

Relations.—Superficially, the deep fascia and superficial veins; deeply, the flexor sublimis and profundus digitorum, the ulnar vessels and nerve. At the elbow the posterior ulnar recurrent artery with the ulnar nerve passes between the two heads of this muscle. Near the wrist the ulnar artery lies along the outer border of the tendon.

Variations.—Its insertion sometimes extends to the anterior annular ligament, and occasionally it sends a slip to the base of the fourth metacarpal bone.

Second Layer

The second layer consists of one muscle—the flexor sublimis digitorum.

FLEXOR SUBLIMIS DIGITORUM

The **flexor sublimis digitorum**—named from its action as a flexor of the fingers, and from its position in relation to the deep flexor (*sublimis* = superficial)—is a fusiform sheet, with two heads above, and dividing into four tendons below.

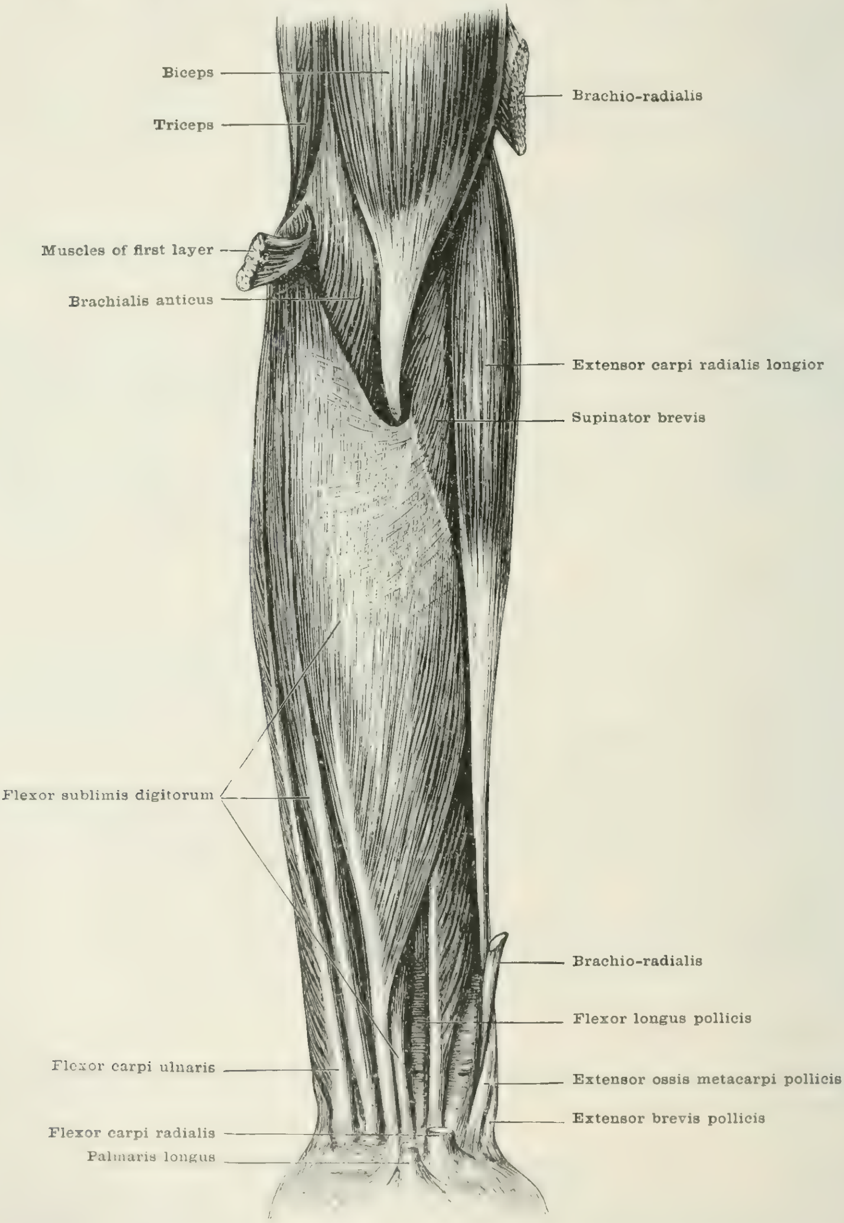
Origin.—The **first head** arises from (1) the front of the internal condyle by the common tendon; (2) the intermuscular septum which separates it from the muscles of the first sheet; (3) the internal lateral ligament; and (4) a tubercle at the upper part of the inner border of the coronoid process of the ulna.

The **second head** arises from the oblique line on the anterior surface of the radius.

Insertion.—By four tendons into the middle of the sides of the second phalanges of the four fingers.

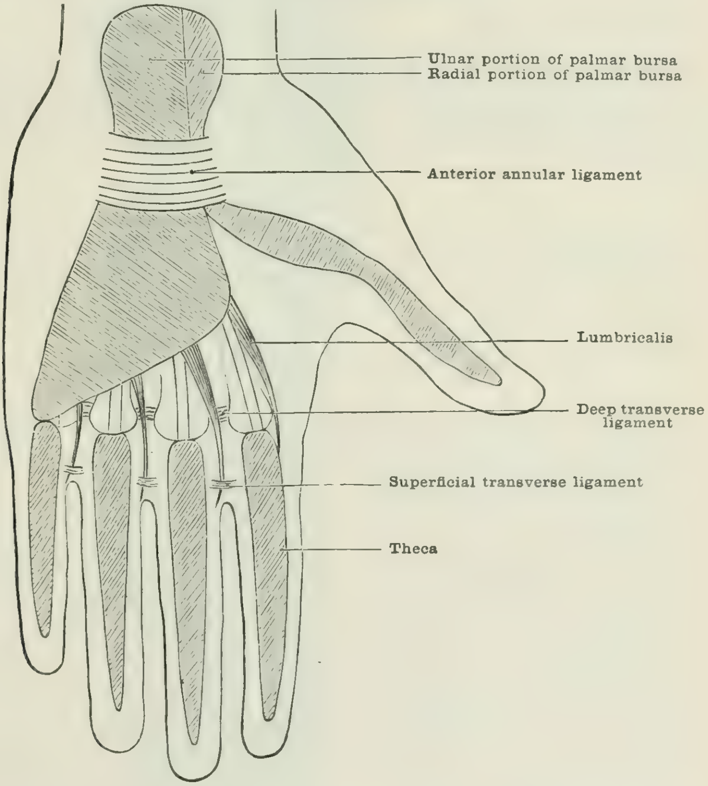
Structure.—The first head arises by short tendinous fibres from the humerus and ulna, and from the ligament between them. The second head, which is much smaller, by fleshy fibres which form a thin sheet covering a part of the flexor longus pollicis. Between these two heads the median nerve and the ulnar artery are placed. Converging from these two heads, the fleshy fibres occupy almost the whole breadth of the forearm, but soon divide into a superficial and deep plane. From the former,

FIG. 273.—FRONT OF THE FOREARM: SECOND LAYER OF MUSCLES.


Biceps
Triceps
Brachio-radialis
Muscles of first layer
Brachialis anticus
Extensor carpi radialis longior
Supinator brevis
Flexor sublimis digitorum
Brachio-radialis
Flexor longus pollicis
Flexor carpi ulnaris
Extensor ossis metacarpi pollicis
Extensor brevis pollicis
Flexor carpi radialis
Palmaris longus

which contains the radial head and the more superficial fibres of the first head, the tendons to the middle and ring fingers are derived. The tendon to the middle finger receives the greater part of the radial head in penniform fashion, becoming free close to the anterior annular ligament. That to the ring finger separates high up, and is soon free from fleshy fibres. The deeper plane of the muscle is crossed by a strong tendinous intersection soon after its origin from the first head. It then gives off a fleshy band to join that part of the superficial plane which goes to the ring finger, and afterwards bifurcates to form the tendons for the index and little fingers. I am indebted to Professor Thane for calling my attention to this arrangement. Beneath the anterior annular ligament the tendons of the superficial plane, viz. those going to the middle and ring fingers, lie in front of the other two tendons. Here they are invested by the synovial sheath or *great palmar bursa*, which is common to them and the other tendons which pass through this space, and which extends from a short distance above the wrist-joint to about the middle of the palm. At the heads of the metacarpal bones the tendons enter the vaginal sheaths of the flexors of the fingers, and each tendon becomes concave behind to correspond with the convexity of the tendon of the deep flexor upon which it now rests. At the middle of the first phalanx the tendon splits, and the halves separate to allow the passage of the tendon of the flexor profundus. The two halves again unite opposite the base of the second phalanx in such a way that the parts now in contact are a direct continuation of what were before the borders of the tendon; while the parts of the tendon which correspond to its mesial line above are now most widely separated (see fig. 280). After a contact of about a quarter of an inch (·6 cm.), the halves of the tendon again separate in order to be attached to the sides of the shaft of the second phalanx.

FIG. 274.—DIAGRAM OF THE GREAT PALMAR BURSA.


Ulnar portion of palmar bursa
Radial portion of palmar bursa
Anterior annular ligament
Lumbricalis
Deep transverse ligament
Superficial transverse ligament
Theca

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the seventh and eighth cervical and first thoracic nerves) by branches from the median nerve which enter the deep surface of the muscle at its upper part.

Action.—To flex the second phalanges of the four fingers. Being inserted very obliquely, it acts under a considerable mechanical disadvantage, but at the same time the speed and range of movement corresponding to a slight contraction of the muscle are very great. The size of the angle which it makes with the shaft of the phalanx at its point of insertion is somewhat increased by the raising of its tendon from the palmar aspect of the first phalanx by the tendon of the deep flexor. After bending the second phalanx of the finger, it will bend also the metacarpophalangeal joint; then the three joints which together produce flexion of the wrist; and finally it will feebly assist in the flexion of the elbow-joint.

Relations.—Superficially, the four muscles of the first sheet and the radial vessels and nerves; deeply, the flexor longus pollicis, flexor profundus digitorum, and pronator quadratus, the ulnar artery and veins, and the median nerve. In the hand, it lies beneath the anterior annular ligament, the palmar fascia, and the superficial palmar arch, and upon the tendons of the flexor profundus digitorum with the lumbricales.

Variations.—The flexor sublimis digitorum varies very little in its origin. It has been seen to arise partly from the pronator radii teres. Occasionally its tendon to the little finger fails, and the place of this tendon may be taken by a lumbricalis or a special slip from the flexor profundus. Sometimes accessory heads join the tendons in the hand from the flexor profundus or the annular ligament.

THIRD LAYER

The third layer consists of two muscles—the flexor profundus digitorum and the flexor longus pollicis—which arise from the ulna and radius respectively.

1. FLEXOR PROFUNDUS DIGITORUM

The **flexor profundus digitorum**—named from its action upon the fingers and its relation to their superficial flexor—is a strong fusiform sheet of muscular fibres which wraps round the anterior and inner surfaces of the ulna, and divides below into four tendons for the fingers.

Origin.—(1) The upper three-fourths of the anterior surface of the ulna; and (2) the adjacent part of the interosseous membrane; (3) the upper two-thirds of the inner surface of the ulna; and (4) the posterior ridge of that bone by the aponeurosis common to it, the flexor carpi ulnaris, and the extensor carpi ulnaris.

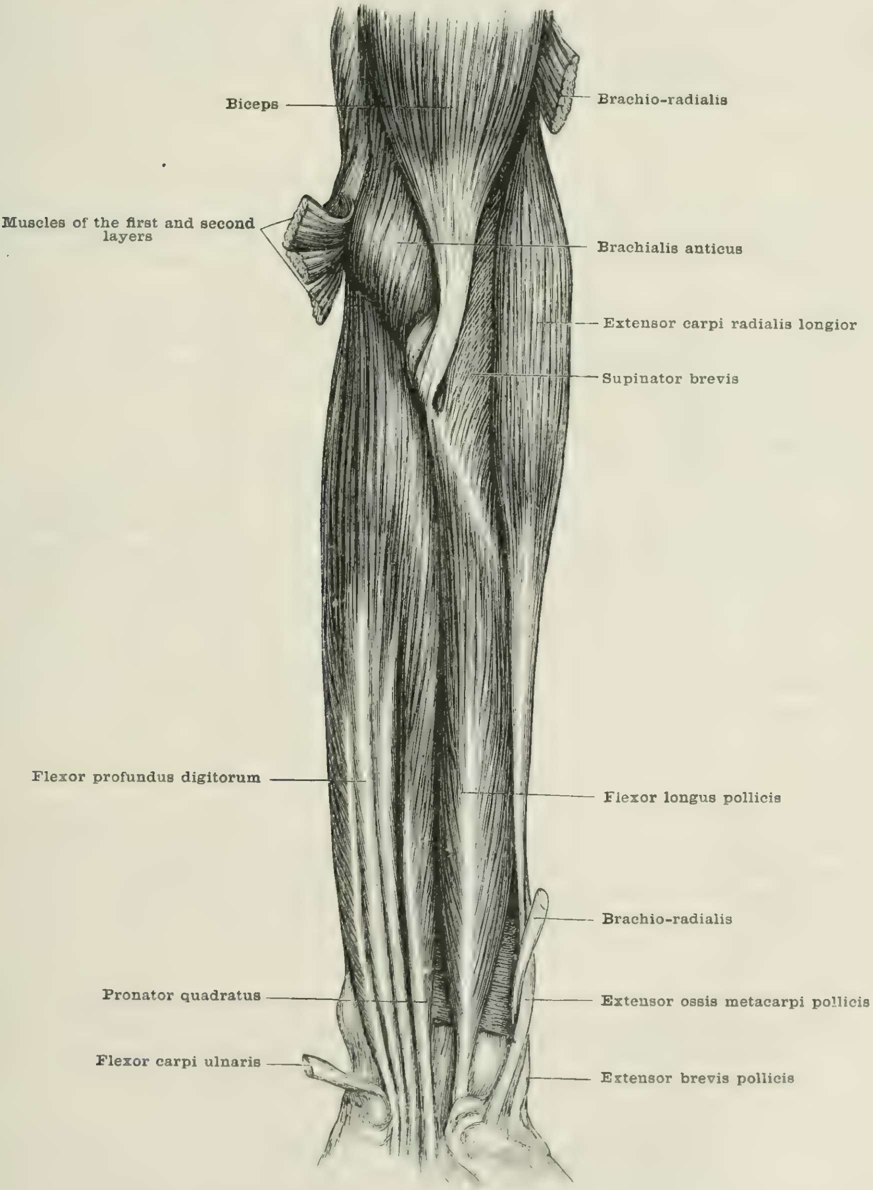
Insertion.—The front of the bases of the third phalanges of the four fingers.

Structure.—Arising directly from the bones and fibrous structures which form the origin of the muscle, the fleshy fibres converge below upon the back of four tendons, which, appearing about the middle of the forearm, become free at the upper border of the anterior annular ligament. That part of the muscle which is inserted into the index finger is separable from the rest of the muscle in nearly the whole of its extent; the part to the little finger is also generally more separable than that to the other two fingers. As they pass beneath the anterior annular ligament, the tendons are invested by the common synovial sheath. At the metacarpophalangeal joints they enter the vaginal sheaths belonging to their respective fingers. Opposite the first phalangeal joint each tendon passes through the opening formed by the splitting of the flexor sublimis tendon; and on the palmar aspect of the second phalanx it passes over a slight elevation formed by the union of the two halves of the companion tendon before they are inserted into the sides of the second phalanx. The deep tendon finally passes over the second phalangeal joint, to be inserted into the front of the base of the third phalanx. In the palm of the hand the lumbricales (which will afterwards be described) arise from the tendons of the flexor profundus.

Nerve-supply.—By two sources from the brachial plexus (through the eighth cervical and first thoracic nerves):—(1) By the anterior interosseous branch of the median nerve, which sends a filament to the portion of the muscle belonging to the index finger, and part if not all of that belonging to the middle finger upon the radial border of its anterior surface, about the middle of the forearm. (2) By the ulnar nerve, which distributes branches to the rest of the muscle near the inner border of the superficial aspect of the muscle in the upper part of the forearm.

Action.—It is a powerful flexor of the third phalanges of the fingers. As with the superficial flexor, the extreme obliquity of the insertion of the tendons gives great speed and range of movement, but increases the mechanical disadvantage with which this muscle (being a representative of the third order of lever) must act. The slight elevation formed by the union of the two halves of each tendon of the flexor sublimis upon the second phalanx diminishes to a small extent the

FIG. 275.—FRONT OF THE FOREARM: THIRD LAYER OF MUSCLES.


Biceps
Brachio-radialis
Muscles of the first and second layers
Brachialis anticus
Extensor carpi radialis longior
Supinator brevis
Flexor profundus digitorum
Flexor longus pollicis
Brachio-radialis
Pronator quadratus
Extensor ossis metacarpi pollicis
Flexor carpi ulnaris
Extensor brevis pollicis

extreme obliquity of its insertion. After bending the third phalanx, the muscle will assist in the flexion of the other phalanges and the wrist.

Relations.—Superficially, the flexor sublimis digitorum and flexor carpi ulnaris, the ulnar vessels, the median and ulnar nerves; deeply, the pronator quadratus and wrist-joint. In the hand, it lies beneath the tendons of the flexor sublimis digitorum and the lumbricales, and upon the adductor of the thumb, the interossei muscles, and the deep palmar arch.

Variations.—The flexor profundus digitorum frequently receives, like the flexor longus pollicis, a slip from the superficial muscles of the forearm. Sometimes the part which goes to the index finger may take part of its origin from the radius; and occasionally slips may pass from the flexor profundus to the flexor longus pollicis, or *vice versâ*. A slip has been observed to end in the synovial membrane of the palmar bursa.

2. FLEXOR LONGUS POLLICIS

The **flexor longus pollicis**—named from its action upon the thumb and its length as compared with the short muscles of the ball of the thumb—is a fusiform sheet.

Origin.—(1) The anterior surface of the radius below the oblique line, with the exception of the last two inches (5 cm.) of the surface; and the adjacent surface of the interosseous membrane. (2) A second head arises from the inner border of the coronoid process of the ulna, but occasionally it may come from the internal condyle of the humerus.

Insertion.—The front of the base of the last phalanx of the thumb.

Structure.—A penniform muscle arising fleshy from the bone and the interosseous membrane. The tendon first appears upon the anterior surface near its ulnar border about the middle of the forearm. It receives the fleshy fibres upon its outer border and posterior surface and becomes free at the level of the wrist-joint, where it enters the canal formed by the anterior annular ligament and the front of the carpus. It is here invested by a special compartment of the great synovial bursa, and this compartment is continuous with the synovial sheath of the tendon as it lies in the thumb. After entering the palm of the hand, the tendon passes beneath the outer head of the flexor brevis pollicis, then through the groove formed by the two sesamoid bones which belong to the tendons of this muscle, and after lying in close contact with the concave palmar surface of the first phalanx of the thumb, it is inserted into the front of the base of the second phalanx.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the eighth cervical and first thoracic nerves) by means of the anterior interosseous branch of the median nerve, which sends filaments to it upon its anterior surface near its ulnar border about the middle of the forearm.

Action.—It is a powerful flexor of the last phalanx of the thumb. It will also flex its metacarpo-phalangeal joint, and afterwards it will assist the other flexors of the wrist.

As the bones of the thumb are not in the same plane with those of the fingers, but rotated so that their palmar surface looks towards the rest of the hand, their flexion will be accompanied by adduction; as when the thumb meets the other fingers in picking up any small object, or in grasping anything between the fingers and thumb.

Relations.—Superficially, the flexor sublimis digitorum, flexor carpi radialis, brachio-radialis (supinator longus), and the radial vessels; deeply the pronator quadratus and wrist-joint. In the hand, after passing beneath the anterior annular ligament, it is covered by the opponens pollicis and the outer head of the flexor brevis pollicis, and it lies on the inner head of the flexor brevis pollicis.

Variations.—Besides the communication with the flexor profundus digitorum, we occasionally find slips passing from the tendon of the flexor longus pollicis to join the first lumbricalis muscle. The second head may be absent, as in fig. 275.

FOURTH LAYER

The fourth layer consists of one muscle—the pronator quadratus.

PRONATOR QUADRATUS

The **pronator quadratus** (fig. 284) is a thin quadrilateral sheet, named from its action and its nearly square shape.

Origin.—The inner part of the front surface of the lower fourth of the ulna.

Insertion.—The lower two inches (5 cm.) or rather less of the outer border and the anterior surface of the radius.

Structure.—The greater part of the muscle consists of fleshy fibres which pass transversely between its two attachments. Its inner third, however, is covered by a strong aponeurosis which arises from the inner border of the ulna. The radial insertion is of a somewhat triangular shape, the outer side of the triangle passing obliquely from the interosseous line downwards, and joining the outer border of the radius a short distance from the base of the styloid process; while the inner side corresponds to the interosseous ridge, and the base crosses the front of the radius above the attachment of the anterior radio-carpal ligament.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the eighth cervical and first thoracic nerves) by means of the anterior interosseous branch of the median nerve which terminates by filaments which enter the front of the muscle near its upper border.

Action.—By drawing the outer border of the anterior surface of the radius towards the inner border of the anterior surface of the ulna, it pronates the radius upon the ulna.

Relations.—Superficially, the flexor longus pollicis, the flexor carpi radialis, the flexor profundus digitorum, and the flexor carpi ulnaris, the radial artery, and the ulnar nerve; deeply, the anterior interosseous artery, the interosseous membrane, and the inferior radio-ulnar joint.

Variations.—The pronator quadratus is sometimes absent. It sometimes gives off slips to the scaphoid or trapezium, the base of the first metacarpal bone, or to the origins of the short thumb muscles.

RADIAL GROUP OF MUSCLES

Along the radial border, between the groups which clothe the front and back of the forearm, lie three long muscles, one upon the other—viz. the brachio-radialis (or supinator longus); the extensor carpi radialis longior; and the extensor carpi radialis brevior.

1. BRACHIO-RADIALIS

The **brachio-radialis, or supinator radii longus**—named from its attachment to the humerus and radius, and sometimes called the supinator longus from an erroneous view of its action—is a fusiform sheet.

Origin.—The upper two-thirds of the external condylar ridge, and the front of the external intermuscular septum of the upper arm.

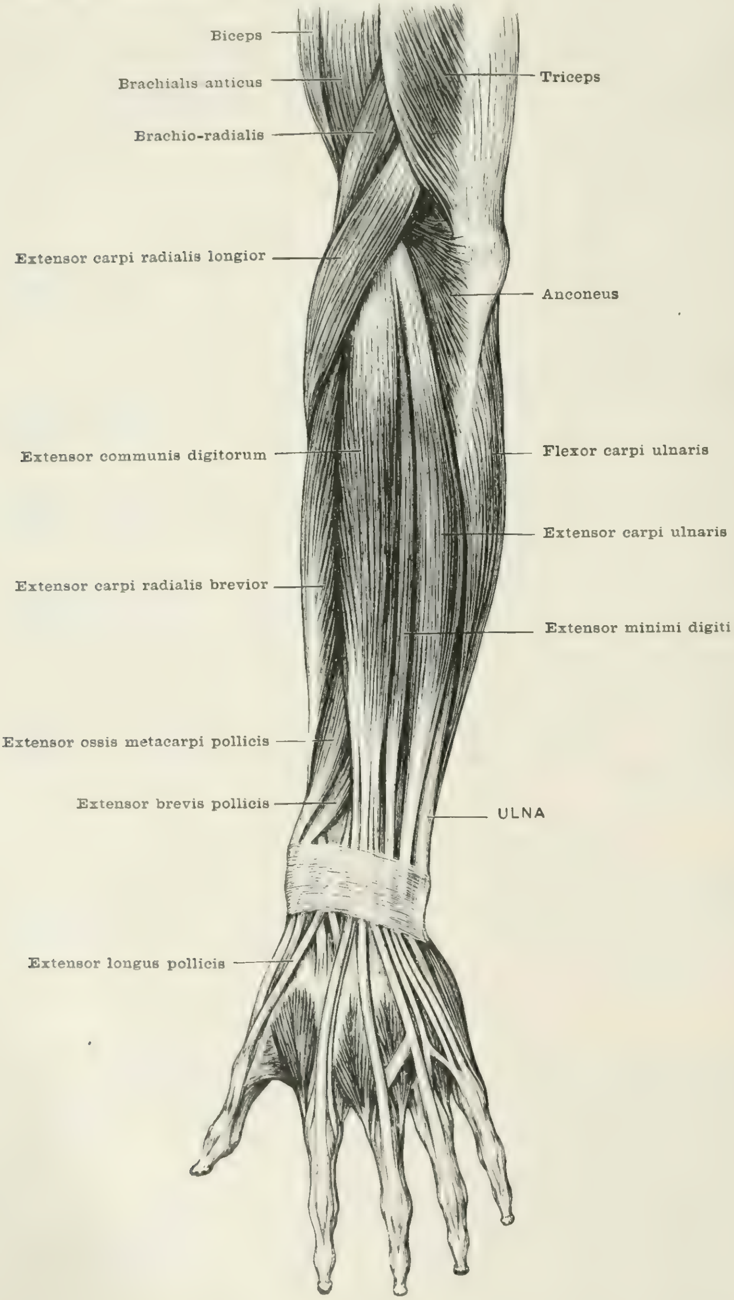
Insertion.—The base of the styloid process of the radius.

Structure.—Arising by fleshy fibres from the septum, and by short tendinous fibres from the condylar ridge, the muscle passes downwards and forwards in penniform fashion to its tendon which lies first on its deep surface. Becoming free just below the middle of the forearm, the tendon runs directly downwards and expands before its insertion upon a horizontal line at the base of the styloid process of the radius. At first the plane of the muscle is directed outwards and inwards; but lower down the outer surface becomes anterior, and the inner posterior.

Nerve-supply.—From the posterior cord of the brachial plexus (through the sixth cervical nerve), by branches from the musculo-spiral nerve which enter the upper part of the muscle upon its inner surface.

Action.—To flex the forearm. Its insertion at the lower end of the long arm formed by the radius makes it one of the few examples of the second order of lever when the muscle is used to raise only the weight of the forearm; but whatever advantage is obtained by the position of this insertion is lost by the extreme

FIG. 276.—MUSCLES OF THE RADIAL SIDE AND THE BACK OF THE FOREARM.


Biceps
Triceps
Brachialis anticus
Brachio-radialis
Extensor carpi radialis longior
Anconeus
Extensor communis digitorum
Flexor carpi ulnaris
Extensor carpi ulnaris
Extensor carpi radialis brevior
Extensor minimi digiti
Extensor ossis metacarpi pollicis
Extensor brevis pollicis
ULNA
Extensor longus pollicis

obliquity of the tendon. This obliquity (Introduction, page 286) will, however, add speed and range of movement, and at the same time it will assist in drawing the articular surfaces of the elbow together, and so give strength to the joint.

If the forearm be fully supinated, the contraction of the brachio-radialis will cause some pronation; and it is only when the forearm is in the position of full pronation that it will produce a slight supination. It is therefore incorrect to describe the muscle as a supinator.

Relations.—In the upper arm, it has at its inner side the brachialis anticus, in which it forms a deep groove, and the musculo-spiral nerve and superior profunda vessels. Outside and behind lies the inner head of the triceps. Below, it rests on the upper border of the extensor carpi radialis longior. In the forearm it is covered, above by the deep fascia and superficial veins; below, by the extensor ossis metacarpi and the extensor brevis pollicis. Beneath it lie the extensor carpi radialis longior, the supinator brevis, the pronator radii teres, the flexor sublimis digitorum, the flexor longus pollicis, and the radial vessels and nerve.

Variations.—The brachio-radialis is sometimes absent. It may receive a slip from the brachialis anticus. It may give slips to various parts of the radius, to the carpal bones on the radial side of the hand, to the tendons of the extensor carpi radialis longior, the extensor ossis metacarpi pollicis, the flexor longus pollicis, or to the supinator brevis muscle.

2. EXTENSOR CARPI RADIALIS LONGIOR

The **extensor carpi radialis longior**—named from its action, position, and length in comparison with its fellow extensor—is a narrow fusiform sheet.

Origin.—(1) The lower third of the external condylar ridge; (2) the front of the external intermuscular septum; (3) the front of the common tendon by which the extensors at the back of the forearm arise from the external condyle.

Insertion.—The back of the base of the second metacarpal bone near its radial border.

Structure.—Arising by fleshy fibres, this muscle has a somewhat penniform arrangement. Its tendon is first seen near the outer border on the deep surface of the muscle, and becomes free at the junction of the middle and upper thirds of the forearm. It lies upon and in close association with the tendon of the short extensor, and passes through the second compartment in the posterior annular ligament to its insertion upon the metacarpal bone. Its surfaces, like those of the preceding muscle, are at first directed outwards and inwards, and afterwards forwards and backwards.

Nerve-supply.—From the posterior cord of the brachial plexus (through the sixth cervical nerve), by a branch from the musculo-spiral nerve which enters the muscle at the upper part of its deep surface.

Action.—(1) To extend the wrist; including under this appellation the carpometacarpal, intercarpal, and radio-carpal joints. It is also a slight abductor of these joints. When the fingers have to be bent by the long flexors, it steadies the carpus and metacarpus so as to limit the action of the flexors to the phalanges. (2) It has also some influence in flexion of the elbow-joint.

Relations.—In the arm, it lies between the brachialis anticus and the triceps, and it is covered by the brachio-radialis. In the forearm, it overlies the short radial extensor and wrist-joint, while it lies beneath the brachio-radialis and the extensors of the thumb.

Variations.—The extensor carpi radialis longior may be united with the brevior. It may give tendinous slips to the bases of the first or third metacarpal bones, or to the trapezium; or a slip may join the extensor ossis metacarpi pollicis, or some of the interossei.

3. EXTENSOR CARPI RADIALIS BREVIOR

The **extensor carpi radialis brevior**—named for similar reasons to those which give its name to the preceding muscle—is also flat and fusiform.

Origin.—(1) The common tendon attached to the external condyle; (2) the intermuscular septa which separate it from the origins of the adjacent muscles; and (3) the external lateral ligament of the elbow-joint.

Insertion.—The back of the bases of the second and third metacarpal bones near the lower part of their line of contact.

Structure.—This muscle is thicker than the preceding, and its fibres have a more decidedly penniform arrangement, as they pass from their long fibrous origin obliquely downwards and forwards to the tendon which appears first upon the inner border of the anterior aspect of the muscle about the middle, and is free at the junction of the lower and middle thirds of the forearm. It passes through the second compartment of the posterior annular ligament with the tendon of the preceding muscle. The tendons of this and the preceding muscle are invested in a synovial sheath as they pass through the posterior annular ligament, and a small bursa lies beneath each of them close to its insertion.

Nerve-supply.—From the posterior cord of the brachial plexus (through the sixth and seventh cervical nerves) by filaments from the posterior interosseous branch of the musculo-spiral nerve which enter the upper part of the anterior surface of the muscle.

Action.—(1) To extend the wrist; and (2) to feebly extend the elbow-joint.

Relations.—It is covered by the extensor carpi radialis longior and the tendons of the three thumb extensors. It lies upon the supinator brevis, the pronator radii teres, the outer surface of the radius and the wrist-joint.

Variations.—Its muscular portion may be blended with that of the preceding muscle, or slips may pass between the muscles. The tendon is often divided, and may send separate insertions to the second and third metacarpal bones.

MUSCLES OF THE BACK OF THE FOREARM

The muscles upon the back of the forearm form two layers: the superficial, consisting of those arising from the back of the external condyle of the humerus; and the deep layer, of those which, with one exception, arise from the bones of the forearm only.

The superficial layer continues upon the back of the forearm the series of the radial extensors. It consists of four muscles: the extensor communis digitorum; the extensor minimi digiti; the extensor carpi ulnaris; and the anconeus.

Superficial Layer

1. EXTENSOR COMMUNIS DIGITORUM

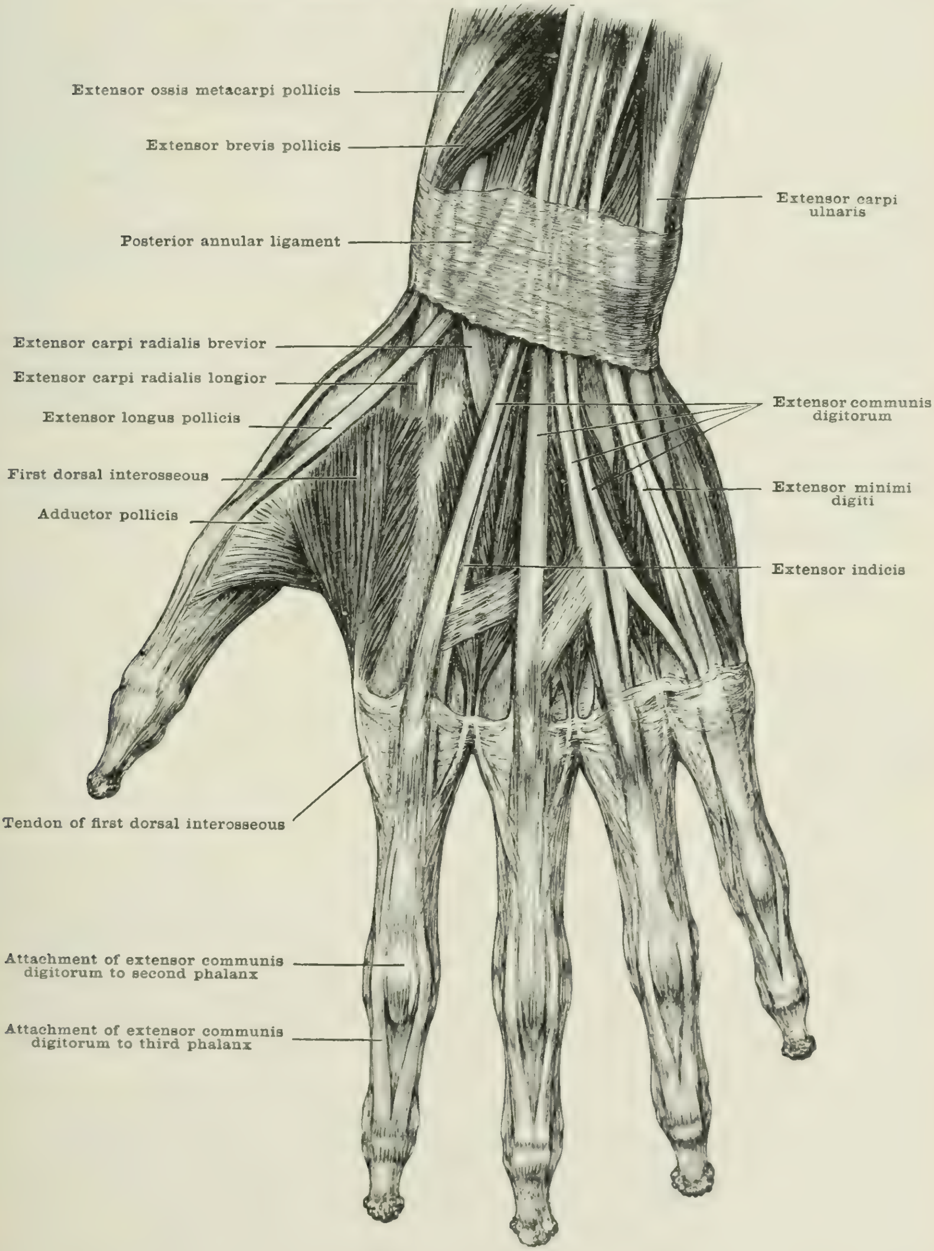
The **extensor communis digitorum**—named from its common action upon the four fingers—is fusiform and somewhat flattened, and divides below into four tendons.

Origin.—(1) The common tendon from the lower part of the external condyle; (2) the deep fascia of the forearm; and (3) the intermuscular septa which separate it from the extensor carpi radialis brevior, the extensor minimi digiti, and the supinator brevis.

Insertion.—(1) The lateral ligaments of the metacarpo-phalangeal joints of the four fingers; the back of the bases of (2) the second, and (3) the third phalanges of the four fingers.

Structure.—Arising from the interior of the aponeurotic case formed by the deep fascia and the intermuscular septa, the fleshy fibres soon break up into separate masses, and converge upon the four tendons which, beginning about the middle of the forearm, become free a short distance above the wrist, and lie side by side in the fourth compartment of the posterior annular ligament; those for the ring and little fingers being more closely connected than the others. After their emergence at the lower border of the ligament, the four tendons, which still retain their flattened cylindrical shape, diverge to their respective fingers. Opposite the heads of the metacarpal bones, each tendon gives off fibrous bands to the lateral ligaments of the corresponding metacarpo-phalangeal joint. Upon the first phalanx the tendon expands into a broad aponeurosis which fits closely by its concave anterior surface upon the back of the bone and affords attachment by its lateral margins to other muscles. After passing over the back of the first phalangeal joint, the central portion of this aponeurosis is inserted into the base of the second phalanx, while its lateral portions converge and, passing over the second phalangeal joint, are attached to the back of the base of the ungual phalanx. A transverse band usually unites the

FIG. 277.—TENDONS UPON THE DORSUM OF THE HAND.


Extensor ossis metacarpi pollicis
Extensor brevis pollicis
Extensor carpi ulnaris
Posterior annular ligament
Extensor carpi radialis brevior
Extensor carpi radialis longior
Extensor communis digitorum
Extensor longus pollicis
First dorsal interosseous
Extensor minimi digiti
Adductor pollicis
Extensor indicis
Tendon of first dorsal interosseous
Attachment of extensor communis digitorum to second phalanx
Attachment of extensor communis digitorum to third phalanx

tendons of the index and middle fingers above the heads of the metacarpal bones. A stronger band passes downwards and outwards from the ring finger tendon to that of the middle finger at the same level. The fourth tendon divides into two parts. The one joins with the tendon of the ring finger, which immediately afterwards gives off a transverse band to the extensor tendon of the little finger, and the other part joins the tendon of the extensor minimi digiti upon the metacarpal bone of the little finger.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve) by several branches from the posterior interosseous division of the musculo-spiral nerve which enter the upper part of the deep surface of the muscle.

Action.—(1) Chiefly to extend the first phalanges of the fingers. (2) It has some power of extending the second and third phalanges; but this part of the tendon of the muscle is chiefly under the control of the lumbricales and interossei, which are attached to the sides of the expansion covering the first phalanx. After extending the fingers, it will also (3) help in the extension of the wrist; and (4) to a slight extent, of the elbow-joint. The bands by which the tendons are attached to one another upon the back of the hand hinder independent extension, especially in the ring finger. The little and index fingers, having special extensors, do not labour under this disadvantage.

Relations.—Superficially, the deep fascia and posterior annular ligament; deeply, the supinator brevis, the extensors of the thumb, the extensor indicis, the dorsal interossei, the posterior and anterior interosseous arteries, the posterior interosseous nerve, the wrist and carpal joints; on the radial side is the extensor carpi radialis brevior; and on the ulnar, the extensor minimi digiti.

Variations.—Some of the tendons may be deficient, or more frequently the muscle divides into more than four tendons, two or even three of which may be attached to one finger. Occasionally a tendon joins that of the extensor longus pollicis.

2. EXTENSOR MINIMI DIGITI

The **extensor minimi digiti**—named from its action upon the little finger—is small and fusiform.

Origin.—(1) The common tendon from the back of the external condyle by a long fibrous process; (2) the deep fascia; and (3) the intermuscular septa which intervene between it and the adjacent muscles.

Insertion.—With the corresponding tendon of the preceding muscle.

Structure.—Arising from the interior of the elongated case formed by the various aponeuroses which diverge from the back of the external condyle, the fleshy fibres, which do not begin till some distance below that point, are inserted into the radial border of a tendon which begins about the middle of the forearm, and becomes free a short distance above the wrist-joint, a little higher than that of the corresponding part of the preceding muscle. Passing through the fifth compartment of the posterior annular ligament, which lies upon the line of junction of the radius and ulna, the tendon reaches the back of the fifth metacarpal bone, and there blends with the fourth tendon of the extensor communis digitorum immediately above the metacarpo-phalangeal joint.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve), by a branch from the posterior interosseous division of the musculo-spiral which enters the deep surface of the upper part of the muscle.

Action.—(1) To extend the first phalanx of the little finger; (2) to extend the second and third phalanges; (3) to extend the wrist; and (4) very slightly the elbow also.

Relations.—Superficially, the deep fascia of the forearm and the posterior annular ligament; deeply, the supinator brevis, the extensors of the thumb, and the extensor indicis, the inferior radio-ulnar joint, and the posterior interosseous artery. On the outer side lies the extensor communis digitorum; and on the inner, the extensor carpi ulnaris.

Variations.—The extensor minimi digiti is rarely absent, but it is sometimes blended with the preceding muscle. Its tendon is often divided, sometimes into as many as three slips.

3. EXTENSOR CARPI ULNARIS

The **extensor carpi ulnaris**—named from its action upon the carpus and its position on the ulnar border of the forearm—is a fusiform sheet.

Origin.—By two heads. The **first head**: (1) By the common tendon from the back of the external condyle; (2) the front of the deep fascia of the forearm; and (3) the intermuscular septa which separate it from the extensor minimi digiti, the anconeus, and the supinator brevis.

The **second head**: from the posterior border of the ulna, by the aponeurosis common to it, the flexor carpi ulnaris, and the flexor profundus digitorum.

Insertion.—The back of the base of the fifth metacarpal bone, close to its ulnar border.

Structure.—The fleshy fibres converge below upon the tendon of insertion, which, beginning in the interior of the muscle in the middle of the forearm, soon becomes visible upon the radial border of the back of the muscle. It receives fleshy fibres in penniform fashion upon its ulnar border and deep surface nearly as far as the wrist, where it enters the sixth compartment of the posterior annular ligament, and lies in a special groove to the outer side of the styloid process of the ulna.

Nerve-supply.—From the posterior cord of the brachial plexus (through the eighth cervical nerve) by branches from the posterior interosseous division of the musculo-spiral nerve which enter the deep surface of the muscle about the middle of the forearm.

Action.—(1) To extend the wrist, acting upon the three articulations involved in this movement; (2) to adduct the wrist, especially when the hand is pronated; (3) it will also help in the extension of the elbow-joint.

Relations.—Superficially, the deep fascia of the forearm, and the posterior annular ligament; deeply, the supinator brevis, the extensors of the thumb, extensor indicis, posterior interosseous artery, the inner half of the posterior surface of the ulna below the middle of the forearm, the wrist, and some carpal joints. On the outer side lies the extensor minimi digiti; on the inner, the anconeus muscle.

Variations.—Frequently a small slip of tendon passes downwards to join the tendon of the preceding muscle, the first phalanx, or the head of the metacarpal bone. Occasionally the fourth or even the third metacarpal bone may receive a slip.

4. ANCONEUS

The **anconeus**—named from its intimate relation with the elbow (*ἀγκών*)—is a triangular fan-shaped sheet.

Origin.—(1) The lower part of the back of the external condyle; and (2) the adjacent part of the posterior ligament of the elbow-joint.

Insertion.—The rough triangular impression upon the outer surface (1) of the olecranon, and (2) of the upper third of the back of the ulna.

Structure.—This muscle is a continuation downwards of the lower part of the inner head of the triceps. Arising by a short tendon, which is prolonged upon the deep surface of the muscle and along its outer border, the fleshy fibres diverge in a fan shape, and are inserted either directly or by short tendinous fibres into the large special impression upon the ulna; the highest fibres being nearly horizontal, and the lowest approaching more nearly to a vertical direction.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh and eighth cervical nerves) by a long branch from the musculo-spiral nerve, which, after passing through the inner head of the triceps muscle, enters the deep aspect of the anconeus close to its upper border.

Action.—To extend the elbow, in association with the triceps, of which some authors consider it to form a fourth head.

Relations.—Superficially, the deep fascia of the forearm; deeply, the supinator brevis, the interosseous recurrent artery which runs through the deeper fibres of the muscle, the elbow and upper radio-ulnar joints; on its outer border, the extensor carpi ulnaris.

DEEP LAYER

The deep layer consists of five muscles: the supinator radii brevis; extensor ossis metacarpi pollicis; extensor brevis pollicis; extensor longus pollicis; and the extensor indicis. Four of these arise from the bones of the forearm, and one only from the humerus also.

1. SUPINATOR RADII BREVIS

The **supinator radii brevis**—named from its action and size in comparison with the brachio-radialis (= supinator longus)—is a rhomboidal sheet of muscular fibre curved upon itself into a somewhat cylindrical shape to wrap round the upper third of the radius.

Origin.—(1) Lower and back part of external condyle; (2) the external lateral ligament of the elbow-joint; (3) the orbicular ligament; (4) the triangular depression below the lesser sigmoid cavity of the ulna, especially along its posterior margin, which forms the upper part of the external border of the ulna.

Insertion.—(1) The back of the neck of the radius; (2) the anterior and outer surfaces of the radius above and at the upper border of the oblique line.

Structure.—Its origin is partly fleshy and partly by a strong aponeurosis which covers the upper half of the muscle and gives attachment to some of the muscles in the superficial layer. The line of origin runs downwards and somewhat inwards from the external condyle to the outer border of the ulna, while that of insertion runs downwards and outwards from the tubercle of the radius to the impression for the pronator radii teres.

Between these lines the fleshy fibres run in parallel curves wrapping round the upper third of the radius. The muscle is divided into a small superficial and more extensive deep plane by the posterior interosseous nerve which perforates it on its way to supply the muscles at the back of the forearm. The line of insertion is broken at the tubercle of the radius by a notch in which lies the bursa in front of the attachment of the biceps tendon.

Nerve-supply.—From the posterior cord of the brachial plexus (through the sixth cervical nerve) by branches derived from the posterior interosseous division of the musculo-spiral nerve, which are given off from this nerve as it perforates the muscle.

Action.—To supinate the radius upon the ulna. By its contraction the muscle unwraps itself from the radius; the tubercle of the radius is drawn forwards, and the outer border of the bone backwards; and if the radius at the commencement of action be in the position of complete pronation, it will be caused by this muscle to revolve about the axis which passes through the centre of its head and the middle of the lower extremity of the ulna through nearly 180°.

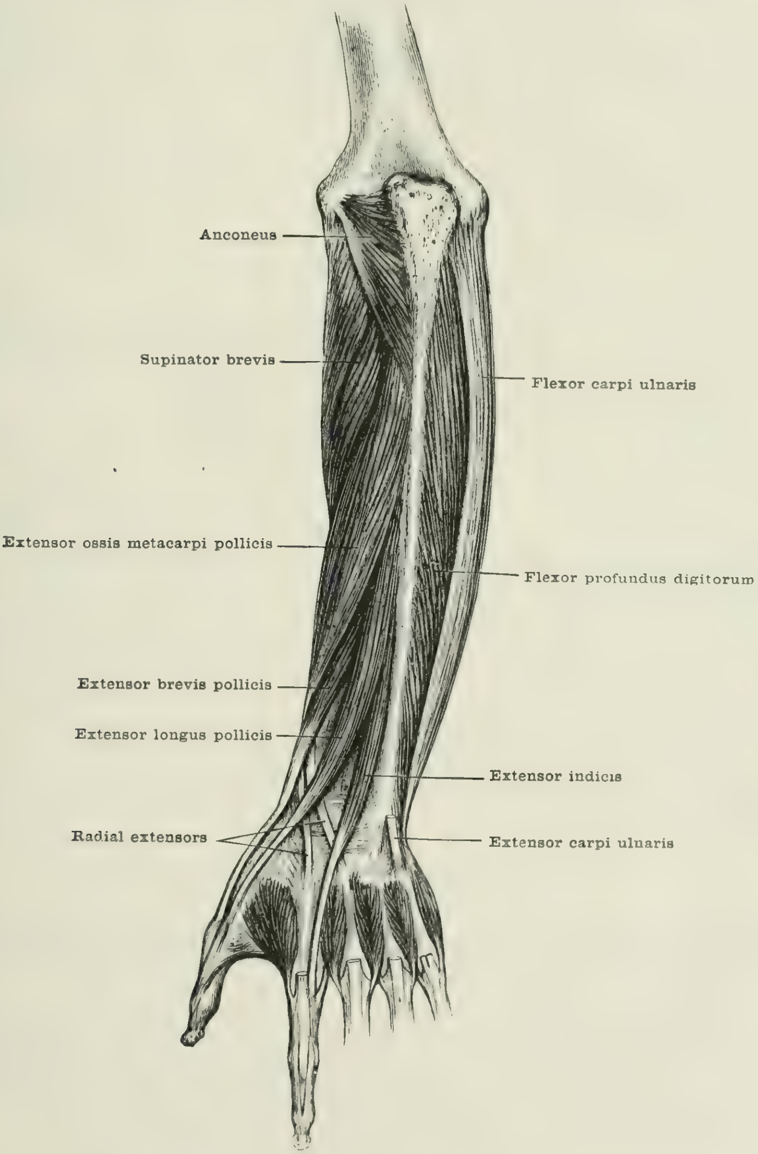
The action of this muscle will, unlike that of the biceps, be unaffected by the position of the elbow.

This completes the list of muscles by which the rotation of the radius upon the ulna is effected. The biceps and supinator brevis are the supinators; the pronator teres and quadratus, the pronators. It should be remembered, however, that ordinary pronation and supination are effected by a more complicated movement than simple rotation of the radius, which would cause the hand to revolve around the axis of the little finger. The usual rotation, the axis of which movement passes through the line of the middle finger, involves a slight flexion and extension of the elbow with some movement of the shoulder-joint.

Relations.—Superficially, the biceps, brachio-radialis, pronator radii teres, extensor carpi radialis brevior, extensor communis digitorum, extensor minimi digiti, extensor carpi ulnaris, anconeus, the radial vessels and nerve, the interosseous recurrent artery; deeply, the superior radio-ulnar joint.

Variations.—A second head has been seen from the humerus near the insertion of the deltoid, and it may receive fibres from the brachio-radialis.

FIG. 278.—THE DEEP LAYER OF THE BACK OF THE FOREARM.


Anconeus
Supinator brevis
Flexor carpi ulnaris
Extensor ossis metacarpi pollicis
Flexor profundus digitorum
Extensor brevis pollicis
Extensor longus pollicis
Extensor indicis
Radial extensors
Extensor carpi ulnaris

2. EXTENSOR OSSIS METACARPI POLLICIS

The **extensor ossis metacarpi pollicis,** or **abductor longus pollicis**—named from its action upon the metacarpal bone of the thumb—is a fusiform sheet.

Origin.—(1) The outer division of the posterior surface of the ulna for a short distance below the junction of the upper and middle thirds of that bone; (2) the adjacent portion of the interosseous membrane; (3) the posterior surface of the radius near the middle of that bone for about two inches (5 cm.) below the insertion of the supinator brevis; and (4) the septa which separate it from the supinator brevis, extensor carpi ulnaris, and extensor longus pollicis.

Insertion.—(1) The small impression upon the radial side of the base of the first metacarpal bone; (2) the fascia covering the ball of the thumb; and frequently (3) the back of the trapezium.

Structure.—A somewhat bipenniform muscular sheet arising by an origin which stretches obliquely downwards and outwards from the back of the ulna, at the upper part of its middle third, to the middle of the back of the radius. The tendon appears first as an aponeurosis upon the anterior aspect of the muscle just below the middle of the forearm. The fleshy fibres pass obliquely downwards and outwards to be inserted upon the posterior face of this aponeurosis. This as it descends thickens into a rounded tendon, which, becoming free from its muscular fibres just above the posterior annular ligament, crosses the back of the two radial extensor tendons, and enters the first compartment of the posterior annular ligament upon the outer surface of the lower end of the radius. After leaving this compartment, the tendon passes vertically downwards, lying upon the external lateral ligament of the wrist-joint and the radial artery, to be inserted into the first metacarpal bone. From its anterior border a strong aponeurosis is given off to that part of the palmar fascia which covers the ball of the thumb, and which forms a part of the origin of the abductor pollicis. Frequently this division of the insertion is indicated by a groove running up the tendon, or by a more complete separation which may extend as high as the fleshy fibres of the muscle.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve) by filaments derived from the posterior interosseous division of the musculo-spiral nerve which enter the muscle upon the upper part of its superficial aspect.

Action.—(1) It abducts and extends the first metacarpal bone, drawing the thumb away from the middle line of the hand, and slightly forwards. (2) It abducts the wrist. It should be remembered that on account of the plane of the thumb being different to that of the palm and fingers, its abduction involves a considerable forward movement, which must not be confounded with flexion.

Relations.—Superficially, the extensor communis digitorum, extensor minimi digiti, extensor carpi ulnaris, the posterior interosseous artery, and posterior annular ligament; deeply, the extensor brevis and the extensor longus pollicis, the two radial extensors, the radial artery, and the wrist-joint.

Variations.—The extensor ossis metacarpi pollicis may receive an accessory slip from the radial group of extensors.

3. EXTENSOR BREVIS POLLICIS

The **extensor brevis pollicis**—sometimes called the **extensor primi internodii pollicis**, from its action upon the first phalanx (internodius) of the thumb—is flat and fusiform.

Origin.—(1) The middle of the posterior surface of the interosseous membrane just below the preceding muscle; (2) an elongated impression upon the inner part of the posterior surface of the radius extending from the middle of that bone for about three inches (7·5 cm.) downwards and slightly outwards; (3) an aponeurosis which separates it from the preceding muscle.

Insertion.—The back of the base of the first phalanx of the thumb.

Structure.—A penniform muscle arising by short tendinous fibres. These soon become fleshy, and pass downwards and outwards to a tendon which begins in the lower third of the forearm upon the radial border of its superficial aspect. Lying beneath the tendon of the preceding muscle and in close connection with it, this tendon passes over the tendons of the radial extensors, runs through the first compartment of the posterior annular ligament, crosses the first metacarpo-phalangeal joint on the ulnar side of the tendon of the preceding muscle, and then expands into a broad aponeurosis which is inserted into the whole of the posterior surface of the base of the first phalanx.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve) by a branch from the posterior interosseous division of the musculo-spiral nerve, which enters the upper part of the muscle on the ulnar border of its superficial aspect.

Action.—It is a feeble muscle, the chief function of which is (1) to extend the metacarpo-phalangeal joint of the thumb; at the same time it will assist the extensor ossis metacarpi pollicis in (2) abducting and extending the first metacarpal bone; and afterwards it will assist in (3) the abduction of the wrist.

Relations.—Superficially, the extensor ossis metacarpi pollicis, extensor communis digitorum, extensor minimi digiti, and posterior annular ligament; deeply, the radial extensors, the radial artery, the wrist and first metacarpo-phalangeal joints.

Variations.—The extensor brevis pollicis may be absent, or it may be blended with the preceding muscle. It may have insertions upon the metacarpal bones or the last phalanx. An accessory slip has been observed from the external condylar ridge of the humerus.

4. EXTENSOR LONGUS POLLICIS

The **extensor longus pollicis**, or **extensor secundi internodii pollicis**—named from its action and length—is flat and fusiform.

Origin.—(1) An elongated impression upon the outer part of the posterior surface of the ulna, extending from the middle of that bone for three or four inches (7·5 to 10 cm.) downwards and slightly outwards close to its external border. (2) The adjacent part of the back of the interosseous membrane, and a septum between it and the extensor indicis.

Insertion.—The back of the base of the last phalanx of the thumb.

Structure.—This muscle, which is stronger than the preceding, has also a penniform arrangement. Its fibres pass downwards and outwards from their fleshy origin to be inserted into the tendon upon the back of the muscle, which, appearing about two inches (5 cm.) from its upper extremity near its radial border, gradually thickens as it passes obliquely downwards and outwards. Becoming free from muscular fibres at the upper border of the posterior annular ligament, it enters the deep groove which forms the third compartment beneath that ligament. At the lower extremity of this canal it crosses obliquely the two radial extensor tendons at the back of the wrist-joint, and upon the back of the first metacarpal bone it lies in close contact with the inner border of the tendon of the preceding muscle, and expands into a flat and broad aponeurosis which covers the back of the first phalanx before its insertion into the last phalanx. Whilst spread over the convex surface of the shaft of the first phalanx, it receives small tendinous insertions from the abductor and adductor muscles of the ball of the thumb.

The three tendons of the extensor muscles of the thumb enclose a triangular space which is visible upon the outer side of the wrist-joint, and is bounded by the tendons of the extensor ossis metacarpi pollicis and the extensor brevis pollicis upon its radial side, by the tendon of the extensor longus pollicis upon its ulnar side, and above by the lower end of the radius. Across this triangle stretches the radial artery, in its passage beneath the tendons from the anterior surface of the wrist to the upper part of the back of the first interosseous space.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve), by branches from the posterior interosseous division of the musculo-spiral nerve which enter the upper part of the muscle upon its superficial aspect.

Action.—It is (1) a strong extensor of the second phalangeal joint of the thumb; and afterwards (2) of the first phalanx. It will (3) extend, and at the same time adduct, the first metacarpal bone so as to draw the whole thumb in the extended position backwards, and at the same time inwards. It will also (4) assist in the extension of the wrist, and (5) in the supination of the forearm.

Relations.—Superficially, the extensor ossis metacarpi pollicis, extensor communis digitorum, extensor minimi digiti, extensor carpi ulnaris, posterior interosseous artery, and posterior annular ligament; deeply, the radial extensors, the anterior interosseous and radial arteries, wrist, metacarpo-phalangeal, and phalangeal joints.

Variations.—This muscle may send a slip to the base of the first phalanx of the thumb. It may also receive a tendinous slip from the following muscle.

5. EXTENSOR INDICIS

The **extensor indicis**—named from its action upon the index finger—is flat and fusiform.

Origin.—(1) An elongated impression which stretches downwards and slightly outwards from the junction of the middle and lower thirds of the outer division of the posterior surface of the ulna, immediately internal to the impression for the preceding muscle, but at the same time rather lower down, to within a short distance of the lower extremity of that bone. (2) For a short space from the part of the interosseous ligament which is adjacent to the lower part of this impression. (3) The septum between it and the preceding muscle.

Insertion.—The inner side of the aponeurosis of the first tendon of the extensor communis digitorum.

Structure.—This penniform muscle arises by fleshy fibres which pass obliquely downwards and outwards to the anterior surface of a tendon which is first seen upon the radial border of its posterior surface in the lower third of the forearm, and, becoming free just above the wrist, passes beneath the tendon of the extensor minimi digiti, and enters the fourth compartment of the posterior annular ligament, where it lies beneath the inner tendons of the extensor communis digitorum. It is then inserted into the inner edge of the aponeurosis of the tendon of the common extensor belonging to the index finger, at about the level of the metacarpo-phalangeal joint.

Nerve-supply.—From the posterior cord of the brachial plexus (through the seventh cervical nerve), by a branch from the posterior interosseous division of the musculo-spiral nerve which enters the upper part of the muscle near the radial border of its superficial aspect.

Action.—It assists the extensor communis digitorum in (1) extending the index finger, and especially its first phalanx. At the same time, on account of its direction, it will (2) adduct the index finger, while the action of the extensor communis digitorum upon this finger is that of extension combined with abduction. It will then assist feebly in (3) the extension of the wrist.

Relations.—Superficially, the extensor communis digitorum, the extensor minimi digiti, extensor carpi ulnaris, and posterior annular ligament. Deeply, the dorsal interosseous muscle of the second space, the wrist, and some carpal joints.

Variations.—The extensor indicis may give slips to the extensor longus pollicis and to the middle finger. It may receive slips from the posterior carpal ligaments or the bases of the metacarpal bones, and these slips may be inserted into several digits, so as to form an extensor brevis digitorum manûs.

THE FASCIÆ OF THE HAND

The **dorsal fascia** is a thin layer, continuous with the posterior annular ligament, and, like it, composed chiefly of transverse fibres. It covers the extensor tendons, and connects them together upon the back of the hand; and upon the first phalanges it blends with the aponeuroses which succeed to the tendons. Between the fingers it dips down to join the superficial transverse ligament which forms the web by which the bases of the fingers are connected.

A deeper layer of the dorsal fascia covers the back of the dorsal interossei, and is attached to the back of the metacarpal bones.

THE PALMAR FASCIA

The **palmar fascia** takes the place of the deep fascia in the palm of the hand, and is for the most part formed by the expansion of the tendon of the palmaris longus. It is also continuous with the lower margin of the anterior annular ligament. It may be divided into a central and two lateral portions. The central division, which is by far the strongest, is of a triangular shape, the apex being continuous with the tendon of the palmaris longus, and also attached to the lower border of the anterior annular ligament; the base corresponding to the heads of the four inner metacarpal bones. It consists in front of longitudinally arranged bundles of fibrous tissue derived from the palmaris longus tendon, and behind of transverse fibres which continue those of the annular ligament. Below, the fascia divides into four processes which join the ligamenta vaginalia of the finger tendons. Each of these four processes forms a bridge across the tendons, and is inserted, at the sides of the metacarpo-phalangeal joint, into the lateral and the deep transverse ligaments. This strong central portion of the palmar fascia is closely connected upon its anterior surface with the skin by fibrous septa, which form small compartments in which are lodged pellets of the subcutaneous fat. Upon its posterior surface it is smooth and in contact with the synovial membrane of the great palmar bursa above, and of the thecæ below. Between its four processes there are three spaces left through which the digital nerves and arteries emerge. These are bridged over by transverse fibres which connect the processes, and which form the *superficial transverse ligaments* lying in the webs between the fingers.

The **outer division, or thenar fascia,** is that portion of the palmar fascia which covers the ball of the thumb. It is connected above with the anterior annular ligament, the tendon of the palmaris longus, and an aponeurosis from the tendon of the extensor ossis metacarpi pollicis. After covering the short muscles of the thumb, it is continuous below with the ligamentum vaginale of the flexor longus pollicis tendon. The **inner division, or hypothenar fascia,** is of a triangular shape, the base being above and the apex below. Arising from the anterior annular ligament and the deep fascia of the forearm at the inner side of the wrist, it invests the short palmar muscles peculiar to the little finger, and terminates upon the ulnar border of the hand close to the fifth metacarpo-phalangeal joint. It is covered above by the palmaris brevis.

A deep layer of fascia covers the front of the interossei muscles, and is attached by thin longitudinal septa to the posterior surface of the central part of the palmar fascia.

The **ligamenta vaginalia** are strong bands of transverse fibres which are attached to the borders of the first and second phalanges, and serve to bind in their places the long flexor tendons. Opposite the joints the ligaments are thin, and composed chiefly of obliquely decussating fibres.

The **sheaths of the flexor tendons,** or **thecæ** as they are called, are blind tubes of synovial membrane which invest the back of the ligamenta vaginalia and the front of the three phalanges and the interphalangeal joints. They extend from the metacarpo-phalangeal joint to the middle of the last phalanx: and at the extremities of the tube, the synovial membrane is reflected upon the surface of the flexor tendons. Small folds and cords containing connective tissue and blood-vessels, and invested by the synovial membrane, stretch across the intervening space. These are called **vincula accessoria** (fig. 279). One set of these, the **ligamenta brevia,** are of triangular shape, and pass directly forwards from the front of the lower part of the first and second phalanges to the back of the overlying tendons; while the other set—which are called the **ligamenta longa**—are small cords running downwards and somewhat forwards from the phalanges to the tendons, at a higher level than the ligamenta brevia. The compartment of the palmar bursa belonging to the flexor longus pollicis tendon is continuous with the **theca** of the thumb. The **theca** also of the little finger is close to, and frequently in communication with, the lower part of the great palmar bursa upon its ulnar side (fig. 274).

MUSCLES OF THE HAND

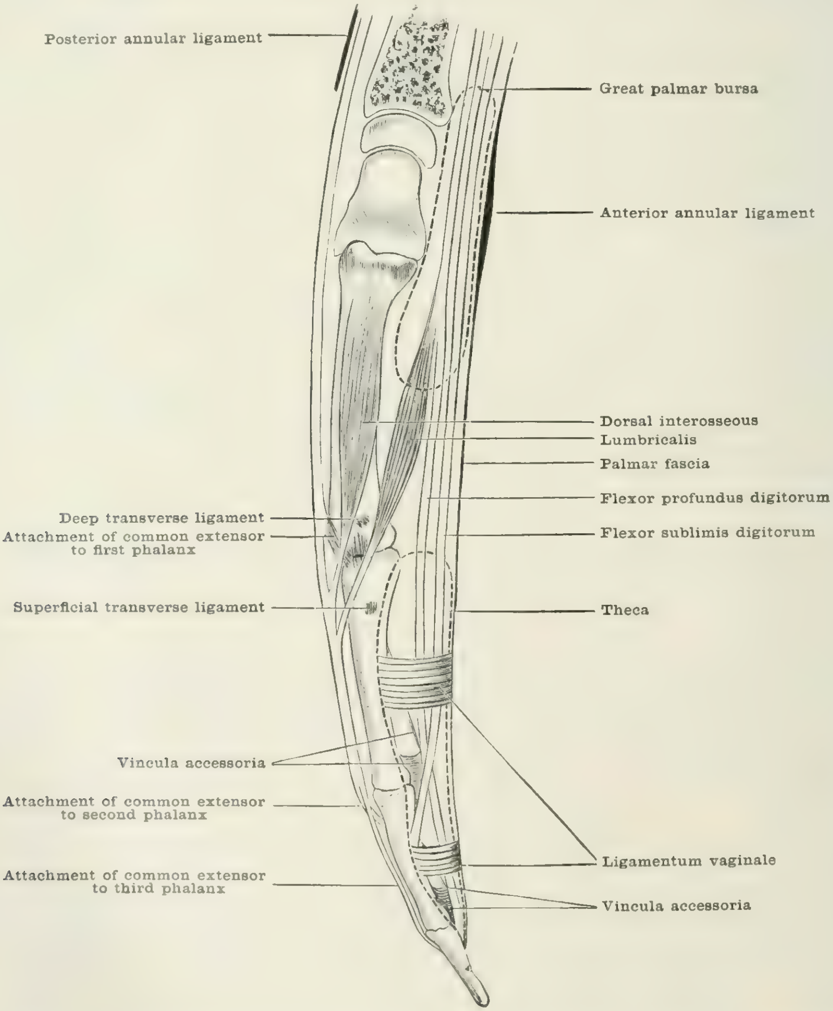
The muscles of the hand proper consist:—first, of a superficial one, which lies upon the palmar fascia; and, secondly, of a deeper set, which may be divided into a central group belonging to the fingers generally, and two other groups, which are associated with the thumb on the radial, and the little finger on the ulnar side of the palm.

SUPERFICIAL MUSCLE OF THE HAND

PALMARIS BREVIS

The **palmaris brevis** (fig. 280)—named from its position in the palm of the hand, and its small size—is a small quadrilateral sheet.

FIG. 279.—DIAGRAM OF A VERTICAL SECTION THROUGH THE MIDDLE OF THE HAND.


Posterior annular ligament
Great palmar bursa
Anterior annular ligament
Dorsal interosseous
Lumbricalis
Palmar fascia
Flexor profundus digitorum
Deep transverse ligament
Flexor sublimis digitorum
Attachment of common extensor to first phalanx
Superficial transverse ligament
Theca
Vincula accessoria
Attachment of common extensor to second phalanx
Ligamentum vaginale
Attachment of common extensor to third phalanx
Vincula accessoria

Origin.—(1) The front of the lower part of the anterior annular ligament about its middle; and (2) the adjacent part of the palmar fascia at the inner edge of its great central division.

Insertion.—The deep surface of the skin and the subcutaneous fat, along the ulnar border of the upper part of the palm.

Structure.—Arising by fleshy and short tendinous fibres, this muscle passes in transverse fasciculi to its insertion, which is of a similar character to its origin. It belongs to that type of muscle of which the panniculus carnosus in the mammalia is the best example, and lies in the subcutaneous tissue superficial to the deep fascia like the platysma myoides and the superficial muscles of the face.

Nerve-supply.—From the inner cord of the brachial plexus (through the first thoracic nerve), by filaments from the superficial division of the ulnar nerve which enter the muscle upon its deep aspect near its upper border.

Action.—It draws the skin and the superficial fascia of the ulnar border of the hand towards the middle line of the palm, forming a deep dimple or groove upon the upper part of the ulnar border of the hand, and at the same time raising the soft parts into a prominent vertical ridge, the object of which appears to be to prevent the ulnar nerve and artery from being pressed upon when a hard substance is grasped by the hand. It also helps to deepen the cup-shaped hollow when the palm is used to convey fluid to the mouth.

Relations.—Superficially, the skin; deeply, the hypothenar fascia, which separates it from the abductor and flexor brevis minimi digiti, and from the ulnar vessels and nerve.

Variations.—This muscle may be entirely absent.

DEEP MUSCLES OF THE PALM OF THE HAND

CENTRAL GROUP

Consisting of two sets of muscles—the lumbricales and the interossei.

1. THE LUMBRICALES

The **lumbricales**—named from their resemblance to earth-worms (= *lumbrici*) —are four small muscles of a fusiform shape.

Origin.—The two outer ones from the outer side of the first and second tendons of the flexor profundus digitorum; the two inner from the adjacent sides of the second and third, and third and fourth tendons of the flexor profundus digitorum respectively. All four are attached to the palmar aspect of the deep flexor, and the origin begins at the lower border of the anterior annular ligament.

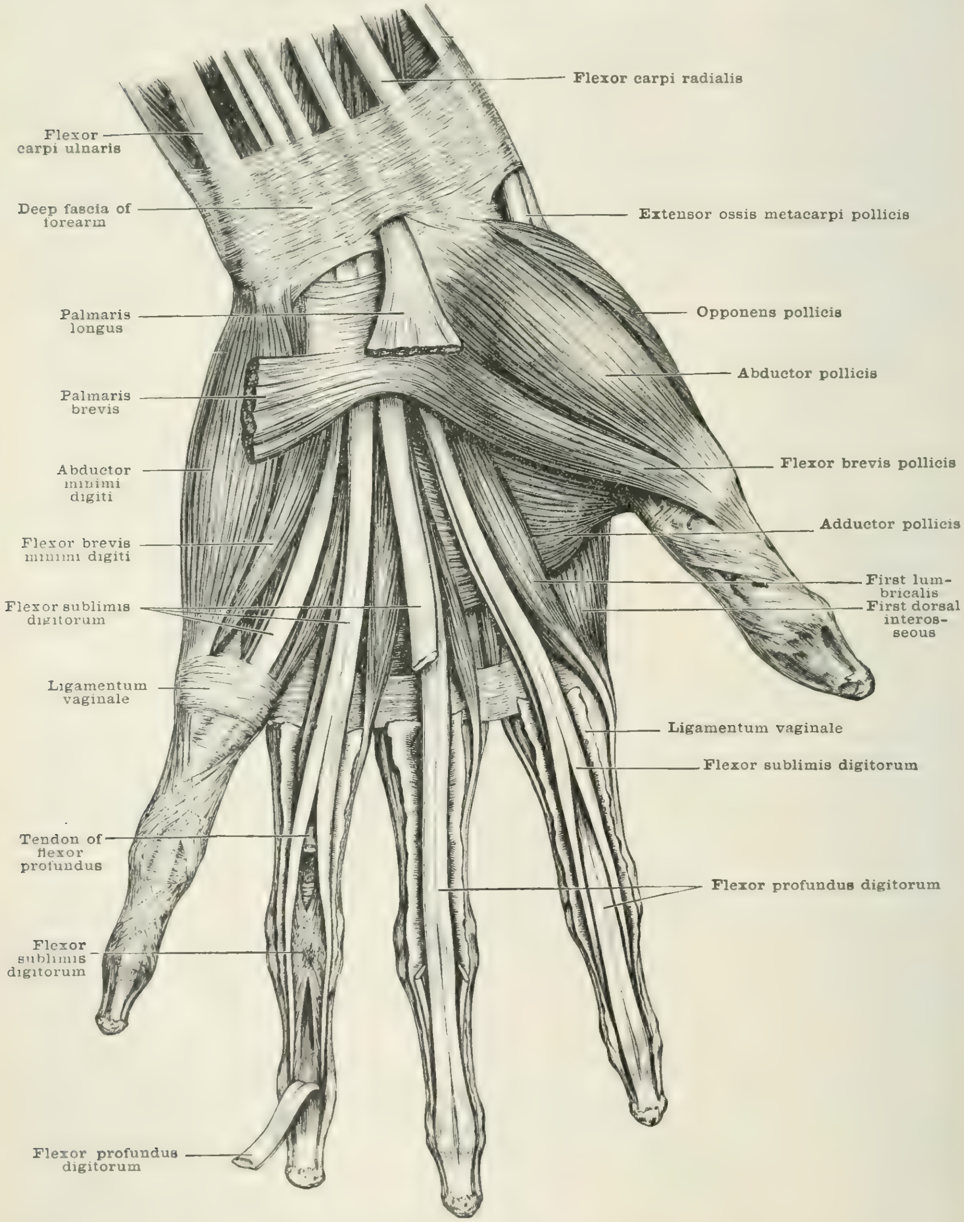
Insertion.—The aponeurosis of the extensor communis digitorum tendon on the radial side of the first phalanx of each of the four fingers.

Structure.—Arising fleshy from the tendons of the deep flexor, the fibres converge upon a small tendon which becomes free a short distance above the metacarpophalangeal joint. The tendon passes in front of the deep transverse metacarpal ligament, below which it expands, and is attached to the border of the extensor tendon.

Nerve-supply.—From the outer and inner cords of the brachial plexus; the first and second receiving small filaments from the digital branches of the median nerve, which enter the muscle near the radial border in the middle third of their palmar aspect. The third and fourth lumbricales are supplied by filaments of the deep branch of the ulnar nerve, which enter their respective muscles in the middle third of their deep surfaces.

Action.—Their chief action will be (1) to flex the first phalanges upon the metacarpal bones; and at the same time (2) to extend the second and third phalanges by their traction upon the sides of the extensor aponeurosis which covers the back of each of the first phalanges. In this action they assist the interosseous muscles; but the lumbricales have this advantage over them, that when the second and third phalanges are flexed by the flexor sublimis and profundus, the lumbricales will flex the first phalanges with increased force, inasmuch as the tendons from which they arise have been retracted, whereas the origins of the interossei are practically fixed. The first and second lumbricales will act feebly as abductors of the index and middle fingers; the third and fourth as adductors of the ring and little fingers. They will also have some influence, together with the interossei, upon the aponeuroses of the extensor communis digitorum tendons in binding them down upon the first phalanges. In this way they perform for the dorsal tendon a similar function to that which is exercised by the ligamentum vaginale upon the two palmar tendons.

Fig. 280.—The Superficial Muscles of the Palm of the Hand.


Flexor carpi radialis
Flexor carpi ulnaris
Deep fascia of forearm
Extensor ossis metacarpi pollicis
Palmaris longus
Opponens pollicis
Abductor pollicis
Palmaris brevis
Abductor minimi digiti
Flexor brevis pollicis
Adductor pollicis
Flexor brevis minimi digiti
First lumbricalis
Flexor sublimis digitorum
First dorsal interosseous
Ligamentum vaginale
Ligamentum vaginale
Flexor sublimis digitorum
Tendon of flexor profundus
Flexor profundus digitorum
Flexor sublimis digitorum
Flexor profundus digitorum

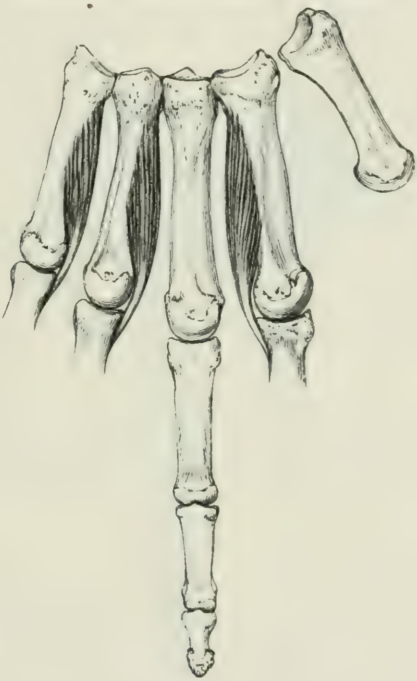
Relations.—Superficially, the tendons of the flexor sublimis digitorum and the superficial transverse ligaments; deeply, the interossei muscles, the adductor and part of the flexor brevis pollicis, and the deep transverse ligaments; on the ulnar side their tendons are in contact with the metacarpo-phalangeal joints.

Variations.—The fourth lumbricalis is sometimes absent. They may vary in their origins, sometimes arising from one, and sometimes from two adjacent tendons. Occasionally one may arise from the flexor longus pollicis tendon. They may be inserted into the ulnar side of a finger, or into the adjacent sides of two fingers.

2. THE INTEROSSEI

The **interossei**—named from their position between the metacarpal bones—are seven in number, three being palmar and four dorsal. They are small muscles, of penniform or bipenniform structure. Both sets are easily exposed to view by a deep dissection in the palm, but the dorsal set is alone visible in the back of the hand.

FIG. 281.—THE PALMAR INTEROSSEI.



The **three palmar interossei** are fusiform in shape.

Origin.—They arise from the sides of the metacarpal bones: the first occupying the whole of the ulnar side of the second metacarpal bone; the second, the radial side of the fourth metacarpal bone; the third, the radial side of the fifth metacarpal bone.

Insertion.—By small tendons (1) into the aponeuroses of the extensor tendons upon the back of the first phalanges of the index, ring, and little fingers; and (2) the adjacent portion of the side of each first phalanx near to its base; the first being attached to the ulnar border, and the second and third to the radial borders of their fingers.

Structure.—Fleshy fibres arising along the whole length of the metacarpal bone are inserted in penniform fashion upon the tendon, which, beginning on the unattached border of the muscle near the middle of the interosseous space, becomes free just above the metacarpo-phalangeal joint, and passes beneath the deep transverse ligament which separates it from the tendon of the lumbricalis muscle.

At this place a small bursa separates the tendon from the deep transverse ligament, and the lateral ligament of the metacarpo-phalangeal joint.

Nerve-supply.—From the inner cord of the brachial plexus (through the eighth cervical nerve), by small filaments which, coming from the deep branch of the ulnar nerve, pass into the upper part of the muscles upon their anterior aspect.

Action and relations.—*Vide infra.*

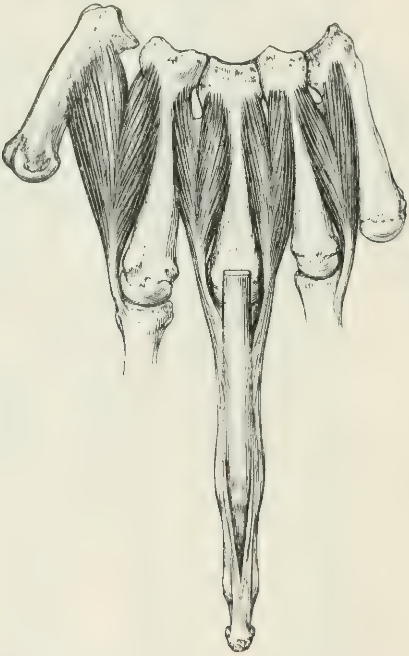
Of the **four dorsal interossei,** the first forms a thick triangular sheet, while the other three are fusiform and prismatic.

Origin.—From the five metacarpal bones, each muscle arising from the adjacent surfaces of the two bones bounding an interosseous space.

Insertion.—(1) Into the sides of the aponeuroses of the extensor communis digitorum tendons; and (2) the adjacent parts of the first phalanges.

Structure.—The fleshy fibres arise from the adjacent surfaces of the metacarpal bones in bipenniform fashion, and converge upon a tendon which, beginning about the middle of the interosseous space, becomes free just above the metacarpo-phalangeal joint, and then passes upon the dorsal aspect of the deep transverse ligament to its insertion into the side of the aponeurosis, and into the upper part of the border of the first phalanx.

FIG. 282.—THE DORSAL INTEROSSEI.



The *first* muscle is thick and by far the strongest, and forms with the adductor pollicis the fleshy web which fills the interval between the metacarpal bones of the thumb and the index finger. Its origin from the first metacarpal bone occupies the upper half of that bone, while that from the second is more extensive. It is inserted into the radial side of the aponeurosis upon the back of the first phalanx as well as into the upper part of the outer border of that bone. The *second* is inserted into the radial side of the aponeurosis upon the first phalanx of the middle finger and into the adjacent bone. The *third* into the ulnar side of the aponeurosis upon the back of the first phalanx of the middle finger and into the adjacent bone. The *fourth* into the ulnar side of the aponeurosis upon the back of the ring finger and the adjacent bone. Of the two heads of each of these muscles, the one arising from the metacarpal bone of the finger into which the muscle is inserted, is always the larger.

Nerve-supply.—From the inner cord of the brachial plexus (through the eighth cervical nerve), by branches from the deep division of the ulnar nerve which enter the muscles at the upper part of their anterior aspect.

Action of the interossei muscles.—First, the *common action of all the interossei* is (1) to flex the first phalanges; and (2) to extend the second and third. Their power of flexion depends upon their insertion into the sides of the first phalanges as well as the edges of the aponeuroses by which the backs of these phalanges are covered. The extension of the second and third phalanges depends upon the fact that the portion of the aponeurosis into which each of them is inserted is continued downwards to the bases of these phalanges. A good example of the action of these muscles and of the lumbricales is given in the movements of the fingers which hold the pen in writing. In forming the light upstroke it will be seen that flexion of the first, accompanies the extension of the second and third phalanges. This movement is due to the contraction of the lumbricales and interossei. On the other hand, the thick downstroke is formed by the extension of the first, and the flexion of the second and third phalanges; this strong movement being due to the action of three powerful muscles, the extensor communis, the flexor sublimis, and the flexor profundus digitorum. Secondly, the *palmar interossei* adduct the index, ring, and little fingers towards the middle line of the hand which passes through the middle finger. Thirdly, the *dorsal interossei* abduct the index, middle, and ring fingers from the middle line of the hand. As the middle finger can be drawn either to the radial or ulnar side from the middle line of the hand, it has two dorsal interossei to abduct it. The first dorsal interosseous muscle will also assist in adducting the thumb.

Relations.—On the palmar surface of the interossei, separated from them by the deep layer of fascia, lie the flexor profundus digitorum tendons and the lumbricales, the adductor and part of the short flexor of the thumb, the deep palmar arch above, and the deep transverse ligaments below; behind, lie the tendons of the extensor communis digitorum and extensor indicis, separated from the dorsal interossei by the deep dorsal fascia.

Variations.—Sometimes the dorsal interossei receive small accessory heads from the posterior carpal ligaments, the lower end of the radius, or the adjacent deep fascia. A part of the first dorsal interosseous has been seen running separately from the front of the metacarpo-phalangeal joint of the thumb to the tendon of the first lumbricalis. Occasionally the second dorsal interosseous is inserted upon the ulnar side of the index finger, so as to resemble the same muscle in the foot.

Muscles of the Thenar Eminence

These are four in number, and they form a fleshy mass at the radial border of the palm, covered by the thenar portion of the palmar fascia, and called the thenar eminence or ball of the thumb. They are the abductor pollicis, the opponens pollicis, the flexor brevis pollicis, and the adductor pollicis.

1. ABDUCTOR POLLICIS

The **abductor pollicis**—named from its action upon the thumb—is a small thick triangular sheet.

Origin.—(1) The tuberosity of the scaphoid bone; (2) the upper part of the ridge on the trapezium; (3) the outer part of the front of the anterior annular ligament; (4) the outer or thenar division of the palmar fascia by which the ball of the thumb is covered; and (5) the slip from the tendon of the extensor ossis metacarpi pollicis which joins this part of the palmar fascia.

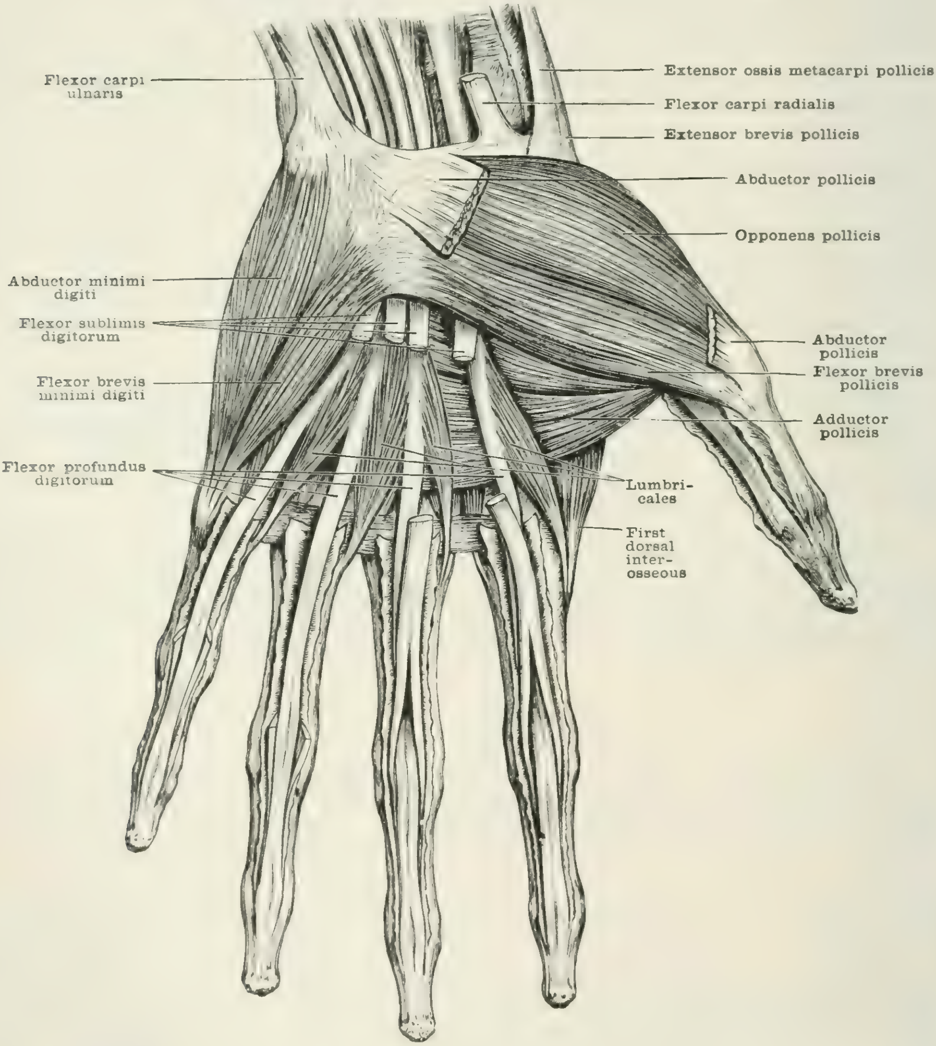
Insertion.—(1) With the outer tendon of the flexor brevis pollicis into the radial side of the base of the first phalanx of the thumb; and into (2) the outer edge of the aponeurosis of the extensor longus pollicis upon the back of the first phalanx.

Structure.—Arising by fleshy or short tendinous fibres from the anterior annular ligament and some or all of the other four origins, the muscle converges upon a short tendon which blends with the adjacent tendon of the flexor brevis.

Nerve-supply.—From the outer and inner cords of the brachial plexus (through the sixth cervical nerve), by a branch from the palmar division of the median nerve, which, after passing under the anterior annular ligament, goes upwards and outwards to enter the upper part of the deep aspect of the muscle near its ulnar border.

Action.—(1) To abduct, and (2) to flex the first phalanx of the thumb. As the bones of the thumb are in a different plane to those of the fingers, this movement will draw the thumb forwards and at the same time slightly inwards. By its insertion into the aponeurosis of the extensor longus pollicis, this muscle will help (3) to extend the last phalanx of the thumb.

Fig. 283.—The Deeper Muscles of the Palm of the Hand.


Flexor carpi ulnaris
Extensor ossis metacarpi pollicis
Flexor carpi radialis
Extensor brevis pollicis
Abductor pollicis
Opponens pollicis
Abductor minimi digiti
Flexor sublimis digitorum
Abductor pollicis
Flexor brevis pollicis
Flexor brevis minimi digiti
Adductor pollicis
Flexor profundus digitorum
Lumbricales
First dorsal interosseous

Relations.—Superficially, the thenar fascia, and the superficialis volæ artery, which usually perforates the muscle; deeply, the outer head of the flexor brevis pollicis and the opponens pollicis.

Variations.—As already mentioned, it receives occasional slips from the radial extensors of the carpus and the extensor ossis metacarpi pollicis. It frequently receives a thin muscular slip from the skin over the trapezium; it may also be supplemented by the opponens pollicis or a small slip from the styloid process of the radius.

2. OPPONENS POLLICIS

The **opponens pollicis,** or **flexor ossis metacarpi pollicis,** is named from its action, as it helps in opposing the thumb to the other fingers and at the same time is a flexor of the first metacarpal bone. It is a short, thick, triangular sheet.

Origin.—(1) The front of the ridge on the trapezium below the preceding; and (2) the lower and outer part of the front of the anterior annular ligament.

Insertion.—The whole of the outer border of the anterior surface of the shaft of the first metacarpal bone.

Structure.—Arising by a short tendinous or fleshy origin, the muscular fibres diverge fanwise to their insertion. The lower border of the muscle is often so blended with the outer head of the next muscle that the separation is somewhat artificial.

Nerve-supply.—From the same source as the preceding; the filaments entering the anterior surface of the muscle near to the upper part of its ulnar border.

Action.—To flex the first metacarpal bone, which it draws forwards and inwards. This movement, on account of the shape of the carpo-metacarpal joint, is accompanied by a certain amount of rotation inwards, by which the palmar aspect of the thumb is made to look backwards and inwards.

Relations.—Superficially, the abductor pollicis and the thenar fascia; deeply, and upon its ulnar border, the flexor brevis pollicis. It also lies upon the joint between the metacarpal bone and the trapezium.

3. FLEXOR BREVIS POLLICIS

The **flexor brevis pollicis**—named from its action and short length in comparison with the long flexor—consists of two heads: each forming a flat triangular sheet.

Origin.—The **outer head** arises from (1) the outer two-thirds of the lower border of the anterior annular ligament; (2) the lower part of the ridge of the trapezium. The **inner head,** from (1) the front of the os magnum; (2) the front of the bases of the first, second, and third metacarpal bones; and (3) from the front of the sheath of the flexor carpi radialis tendon.

Insertion.—The outer and inner sides of the front of the base of the first phalanx of the thumb.

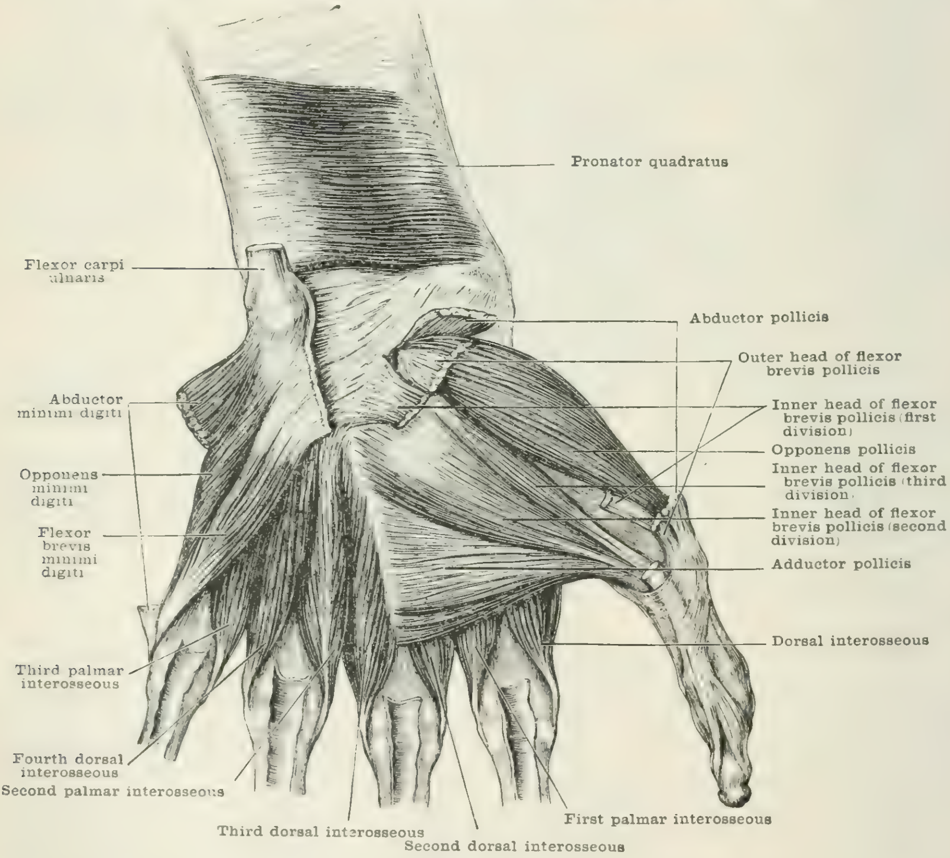
Structure.—Arising by short tendinous as well as by fleshy fibres, the two heads become tendinous a short distance above the first metacarpo-phalangeal joint, and have imbedded in their substance sesamoid bones of a somewhat hemispherical shape, and about one-sixth of an inch (nearly 1 cm.) in diameter, which rest by small articular facets covered with cartilage upon the palmar aspect of the condyles of the first metacarpal bone. Close to their insertion the tendinous fibres are blended with those of the abductor pollicis externally, and the adductor internally. In the **inner head,** three distinct divisions may generally be observed. The *first* or *outermost division* is a small fusiform slip which passes beneath the tendon of the flexor longus pollicis to join the outer head, and to be inserted into the radial sesamoid bone. The *second division* is fan-shaped, and its fibres, which form the greater part of the inner head, converge to embrace the ulnar sesamoid bone. The *third division* lies under cover of the second. It is a small fleshy slip, which arises from the ulnar side of the base of the first metacarpal bone, and passes downwards to be inserted with the adductor pollicis into the ulnar side of the base of the first phalanx. Some authors describe this third division as the **inner head of the flexor brevis pollicis,** and the first and second divisions as the **adductor pollicis obliquus.**

Nerve-supply.—The **outer head** is supplied (through the sixth cervical nerve) by the palmar branch of the median, which enters the middle of its anterior surface near its ulnar border. The **inner head** is supplied (through the eighth cervical nerve) by the deep branch of the ulnar nerve which enters the upper part of its deep surface close to its ulnar border.

Action.—Both heads will flex the metacarpo-phalangeal joint of the thumb. The outer head will flex also the carpo-metacarpal joint, while the inner head will be an adductor as well as flexor of this joint. The former will act in association with the abductor and opponens, and will draw the thumb forwards and inwards, keeping it at some distance from the palm of the hand. The latter will act with the adductor, and draw it more directly inwards in close proximity to the palm of the hand.

Relations.—The outer head lies beneath the abductor pollicis, and in contact by its radial border with the opponens pollicis. The inner head is partly separated from it by the tendon of the flexor longus pollicis; upon its ulnar border it is in contact with the adductor. In front of it lie the tendons of the flexor profundus with the outer lumbricales; behind, are the third part of the radial artery and the interossei muscles of the first two spaces.

FIG. 284.—THE PRONATOR QUADRATUS AND DEEP VIEW OF THE PALM.


Pronator quadratus
Flexor carpi ulnaris
Abductor pollicis
Outer head of flexor brevis pollicis
Abductor minimi digiti
Inner head of flexor brevis pollicis (first division)
Opponens pollicis
Opponens minimi digiti
Inner head of flexor brevis pollicis (third division)
Flexor brevis minimi digiti
Inner head of flexor brevis pollicis (second division)
Adductor pollicis
Dorsal interosseous
Third palmar interosseous
Fourth dorsal interosseous
Second palmar interosseous
First palmar interosseous
Third dorsal interosseous
Second dorsal interosseous

4. ADDUCTOR POLLICIS

The **adductor pollicis**, sometimes called the **adductor pollicis transversus**—named from its action—is a thick triangular sheet.

Origin.—The front border of the shaft of the third metacarpal bone.

Insertion.—(1) The inner side of the base of the first phalanx of the thumb; (2) the inner side of the aponeurosis of the extensor longus pollicis which covers the first phalanx.

Structure.—Arising by short tendinous or fleshy fibres, the muscle converges upon a short tendon, which blends on its outer side with the inner tendon of the flexor brevis pollicis, and sends a fibrous slip to the inner side of the aponeurosis of the extensor longus pollicis.

Nerve-supply.—From the lower cord of the brachial plexus (through the eighth cervical nerve), by the deep branch of the ulnar which sends filaments to the upper border and deep surface near the origin.

Action.—(1) To flex the first phalanx of the thumb; (2) to adduct and flex the carpo-metacarpal joint of the thumb; (3) to extend the second phalanx of the thumb. This latter action of the adductor and abductor pollicis is useful in many of the movements of the thumb, in which it will be found that the second phalanx has to be kept extended, while its palmar aspect is being opposed to the tips of the other digits.

Relations.—Superficially, some of the tendons of the flexor profundus digitorum and the two outer lumbricales; deeply, the abductor indicis and the interossei of the space between the second and third metacarpal bones. Part of the lower border is subcutaneous.

Variations.—The adductor pollicis is often difficult to separate from the inner head of the flexor brevis pollicis.

Muscles of the Hypothenar Eminence

These are three in number—the abductor minimi digiti, the opponens minimi digiti, and the flexor brevis minimi digiti. They lie under cover of the thin internal division of the palmar fascia.

1. ABDUCTOR MINIMI DIGITI

The **abductor minimi digiti**—named from its action—is fusiform and somewhat flattened.

Origin.—(1) The lower half of the pisiform bone; (2) the continuation of the tendon of the flexor carpi ulnaris below this bone.

Insertion.—(1) The ulnar side of the base of the first phalanx of the little finger; and (2) the adjacent portion of the aponeurosis of the extensor minimi digiti.

Structure.—Arising by short tendinous fibres, it soon forms a flat fleshy mass which contracts slightly below, and just before its insertion having again become tendinous, it is for the most part attached to the first phalanx, but it also sends a small slip backwards to the extensor aponeurosis.

Nerve-supply.—From the ulnar nerve through the eighth cervical nerve. It receives small filaments at the outer and deep aspect, usually from the deep palmar division of the ulnar nerve.

Action.—To abduct, and at the same time flex, the metacarpo-phalangeal joint of the little finger; it will also assist, like an interosseous muscle, in the extension of the second and third phalanges.

Relations.—Superficially, the hypothenar part of the palmar fascia and the palmaris brevis; deeply, the flexor brevis and opponens minimi digiti. Upon its radial border are placed the deep palmar branches of the ulnar artery and nerve.

2. FLEXOR BREVIS MINIMI DIGITI

The **flexor brevis minimi digiti**—named from its action—is small and fusiform.

Origin.—(1) The ulnar surface of the hook of the unciform bone; (2) the adjacent part of the front of the anterior annular ligament.

Insertion.—The ulnar side of the base of the first phalanx of the little finger.

Structure.—Its origin and insertion are by short tendinous fibres, and the rest of the muscle is fleshy.

Nerve-supply.—Through the eighth cervical nerve, from the deep branch of the ulnar nerve which sends filaments to the upper part of its deep and ulnar surface.

Action.—To flex the first phalanx of the little finger.

Relations.—Superficially, the hypothenar part of the palmar fascia, the lower part of the abductor minimi digiti, and the superficial palmar arch; deeply, the opponens minimi digiti and the fifth metacarpal bone; and to its radial side lie the flexor tendons of the little finger. This muscle is closely connected with the previous one, from which it is separated above by the deep palmar branches of the ulnar artery and nerve.

Variations.—It may fail, or be blended with the abductor or opponens minimi digiti. An accessory slip may come to it from the lower third of the ulna at its inner border, from the tendon of the flexor carpi ulnaris, or the deep fascia of the forearm.

3. OPPONENS MINIMI DIGITI

The **opponens minimi digiti** (= flexor ossis metacarpi minimi digiti)—named from its action—is a triangular fan-shaped sheet.

Origin.—(1) From the hook of the unciform bone deeper than the preceding; (2) from the adjacent part of the anterior annular ligament.

Insertion.—The whole of the ulnar border and part of the head of the fifth metacarpal bone.

Structure.—Arising by short tendinous fibres, the fleshy bundles diverge downwards and outwards, and are inserted by short tendinous fibres.

Nerve-supply.—Through the eighth cervical nerve, from the deep branch of the ulnar nerve which sends filaments to the upper part of its ulnar aspect.

Action.—To flex the fifth metacarpal bone, and at the same time slightly to adduct it. This movement is observed when the palm is cupped, as when the hand is used to lift water to the mouth.

Relations.—Superficially, the abductor and the flexor brevis minimi digiti; and deeply, the interossei of the fourth interspace, and the deep branches of the ulnar artery and nerve.

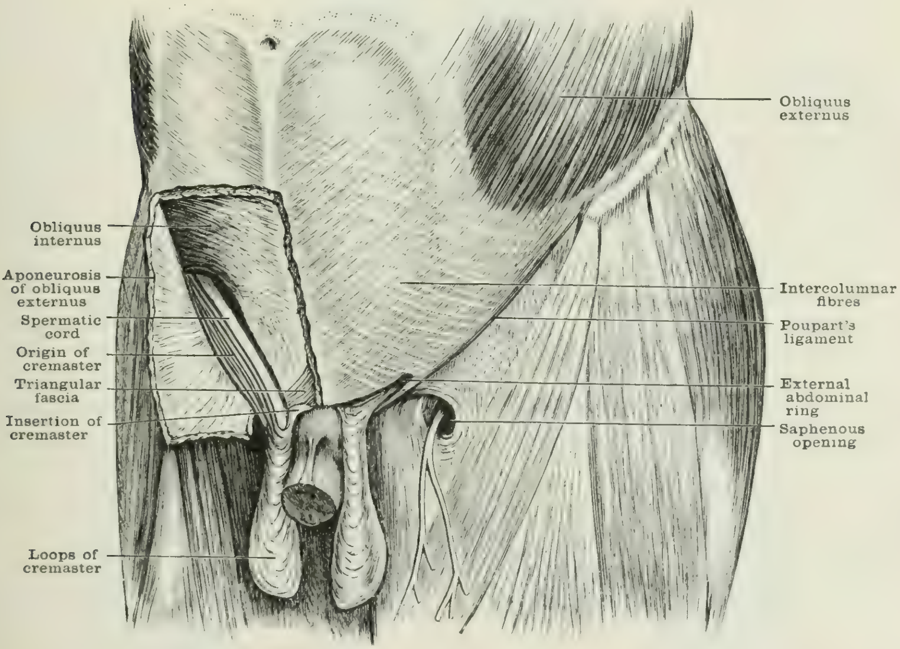
Variations.—It may receive a slip from the deep fascia of the forearm.

THE MUSCLES AND FASCIÆ OF THE THIGH

Superficial fascia.—The greater part of this is of loose adipose tissue, and, without any deep connections, is continuous with the superficial fascia of the abdomen and back. In the upper and front part of the thigh a deep layer of a more membranous structure may be distinguished, and this has deep connections where the lower limb joins the trunk, being attached to the crest of the ilium and to the fascia lata just below its insertion into Poupart's ligament and the rami of the pubis and ischium. Below the inner half of Poupart's ligament several lymphatic glands are arranged longitudinally between these two layers of the superficial fascia.

The **deep fascia** or **fascia lata** is a very strong layer of fibrous tissue, the fibres of which are arranged for the most part transversely as an aponeurosis of investment; but many of them, especially upon the outer side where it is much thicker, are longitudinal, and serve for the insertion of important muscles. The whole of the deep fascia forms a strong cylindrical tube investing all the muscles of the thigh. It is attached above, in the groin, to Poupart's ligament, where it blends with the aponeurosis of the external oblique; on the outer side and behind, to the outer lip of the crest of the ilium, and to the lower part of the vertebral aponeurosis; upon the inner side, to the border of the tuberosity and ascending ramus of the ischium, to the descending ramus of the pubes, the symphysis pubis, and the anterior lip of the crest of the pubes. Below, it becomes much thinner, and is continuous with the deep fascia of the leg; it has also a deep attachment to the tuberosities of the tibia and the outer surface of the head of the fibula. The thickening of its outer portion, which passes down like a tendon to the external tuberosity of the tibia, and is also attached to the outer side of the ligamentum patellæ, is called the **ilio-tibial band.** From the deep surface of this great cylindrical tube are given off various processes which assist in the formation of the sheaths of some of the more superficial muscles. There are also three strong intermuscular septa, which extend from it to the linea aspera in the lower part of the thigh dividing the flexor, extensor, and adductor groups of muscles from one another. At the upper part of the thigh, below the inner third of Poupart's ligament, is the **saphenous opening,** for the passage of the internal saphenous vein, which, after running up the thigh in the superficial fascia, enters the deep femoral vein in this situation. This opening is not, as might have been expected from the character of these openings in other parts, a mere circular foramen. It is formed by the division of the fascia lata into two parts, which do not unite together again, but are inserted separately along the line of attachment of the lower limb to the trunk. It begins below the inner third of Poupart's ligament, and is of a somewhat oval shape, measuring about one inch (2·5 cm.) from above downwards, and half to three-quarters of an inch (1·2 to 2 cm.) from side to side. The lower border of the opening forms a well-defined edge which occupies the angle between the saphenous and femoral veins close to their point of junction. Externally, the fascia lata is attached above along the whole length of Poupart's ligament, and its free internal edge arches inwards towards the spine of the pubes in front of the femoral vein. This external and broad division of the upper part of the fascia lata is called its **iliac portion,** and the free edge which lies in front of the femoral vessels is known by the name of the **falciform border** or **process.** Internally, the fascia lata is in close contact with

FIG. 285.—OBLIQUUS EXTERNUS AND FASCIA LATA.



the pectineus muscle which lies beneath it, and with that muscle it dips beneath the femoral vein and the sheath of the vessels to be attached to the ilio-pectineal line. This internal division is called the **pubic portion** of the fascia lata. The deep layer of the superficial fascia stretches across the opening, and is firmly attached to the edge of the falciform process. From the numerous openings which give passage to the vessels and lymphatics, it is here called the **cribriform fascia** (*cribrum* being the Latin for a sieve).

MUSCLES OF THE FRONT OF THE THIGH

In front of the thigh there is a group of four muscles, the chief function of which is to flex the hip-joint. Two of these muscles arise within the abdomen, and two from the margin of the innominate bone. The two which come from within the abdomen are the psoas and iliacus, and they act together as one muscle, and have been described as such under the name of the ilio-psoas. The third and fourth are the sartorius and pectineus.

1. PSOAS

The **psoas**, or **psoas magnus**—named from the Greek word *ψόα*, meaning the muscles of the loins—is thick, rounded, and fusiform.

Origin.—Inner part, by five processes which arise from (1) the sides of the intervertebral cartilages which intervene between the bodies of the last thoracic and the five lumbar vertebræ; and (2) the adjacent part of the sides of the bodies of these vertebræ; and between these processes from (3) tendinous arches which bridge over the sides of the bodies of the first four lumbar vertebræ. **Outer part,** from the lower border and the front of the transverse processes of all the lumbar vertebræ.

Insertion.—The lower and back part of the lesser trochanter of the femur.

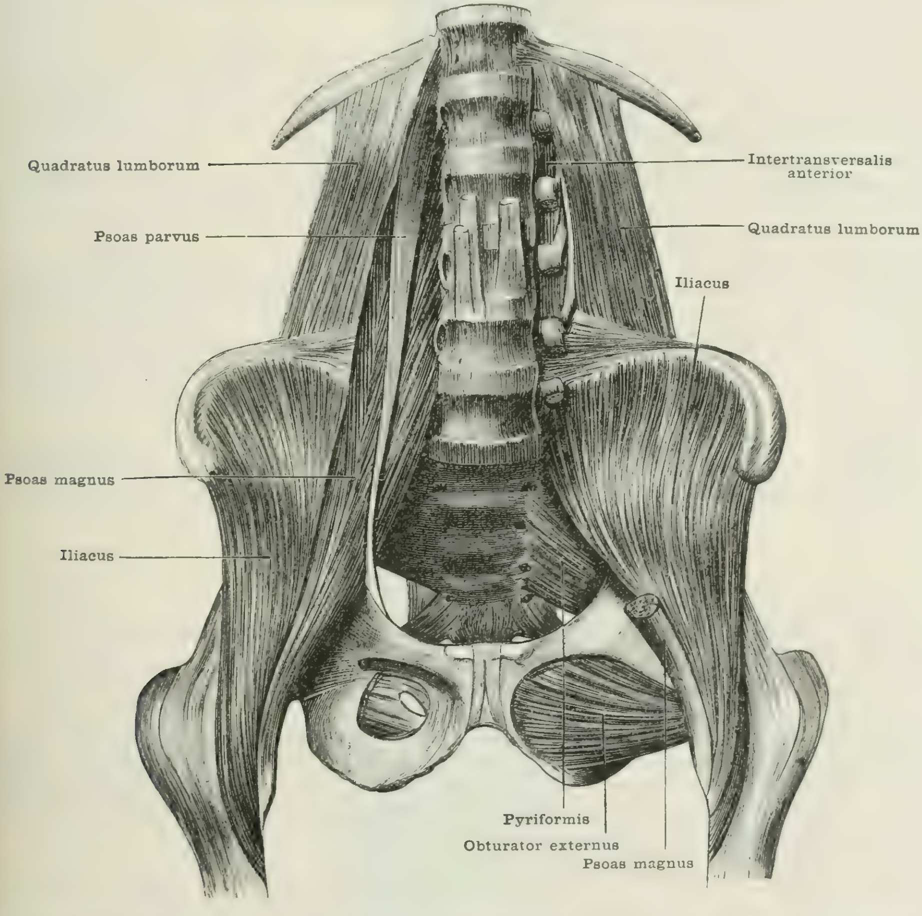
Structure.—With the exception of the small tendinous arches which span the sides of each of the four upper lumbar vertebræ from its upper to its lower border, and which give passage to the lumbar vessels, the whole origin of the muscle is fleshy. The fibres pass downwards and forwards in penniform fashion, but with a slight convergence, to the inner side of the tendon, which, beginning in the interior of the muscle about the level of the crest of the ilium, becomes free upon its outer and posterior surface a short distance above Poupart's ligament, while upon its inner surface it receives fibres down to its insertion. The muscle, having hitherto run in a downward, forward, and slightly outward direction, changes its course at Poupart's ligament, and passes downwards and backwards to be attached to the lesser trochanter of the femur. In its passage along the brim of the pelvis and over the lower part of the iliac fossa, the tendon upon its outer aspect begins to receive the insertion of the iliacus muscle. Between the tendon and the capsule of the hip-joint which is in close connection with it, is placed a bursa which frequently communicates through an opening in the capsule with the interior of the hip-joint.

Nerve-supply.—From the anterior primary branches of the second and third lumbar nerves by filaments which are given off from the lumbar plexus whilst it is passing through the muscle.

Action.—The psoas is a powerful flexor of the thigh upon the pelvis, e.g. in walking, running, or going upstairs. The change in the direction of the tendon after crossing the horizontal ramus of the pubes makes its insertion nearly perpendicular to the axis of the femur. The psoas therefore acts with less mechanical disadvantage than is usual with the muscles of the limbs. It has been sometimes described as an external rotator of the hip; and its insertion into the lesser trochanter at the inner side of the femur would appear to favour this view. In order to determine whether it has this action, it is necessary to ascertain whether the line of the tendon of the psoas lies internal or external to the axis of rotation. This axis may be found by drawing a straight line from the centre of the head of the femur to the centre of gravity of the lower limb, which, when the knee is extended, will be about the middle of the intercondylar notch. By reference to the articulated skeleton it will be seen that on account of the position of the lesser trochanter in the angle which exists between the neck and shaft of the femur, the line of the tendon of the psoas passes either through or external to this axis. The action, therefore of the muscle when the knee is extended will be either to produce no rotation at all, or to rotate inwards. When the knee is flexed or when the thigh is broken the axis of rotation is altered, and in the latter case the psoas may become an external rotator. It will follow, therefore, that any power of rotation exercised by this muscle will be rather internal than external.

Acting from below, the psoas will flex the lower thoracic and the lumbar spine upon the pelvis and the pelvis upon the thigh, as when the body is raised from the reclining to the sitting position, or when the trunk is bent forwards in rowing.

FIG. 286.—PSOAS, ILIACUS, AND QUADRATUS LUMBORUM.



Relations.—The front and inner surfaces are covered by the iliac fascia, which at the upper part of the muscle is thickened, and forms the ligamentum arcuatum internum of the diaphragm. In front lie also the peritoneum, the intestines, the kidney, ureter, and the renal vessels, and the spermatic or ovarian vessels. On the outer side is the iliacus muscle. In the interior of the muscle is the lumbar plexus, the nerves from which run for some distance in its substance. On the inner side lies the external iliac artery; and behind is the inner border of the quadratus lumborum and the brim of the pelvis. In the thigh, after passing beneath Poupart's ligament, it is covered by the femoral artery, the pectineus lies along its inner border, and the capsule of the hip-joint lies behind it, together with the intervening bursa.

Variations.—Sometimes the part of the psoas which arises from the lower lumbar vertebræ forms a distinct muscle. Occasionally fibres from the psoas parvus join the psoas magnus.

2. ILIACUS

The **iliacus**—named from its attachment to the ilium—is a thick, triangular sheet.

Origin.—(1) The upper surface of the ala of the sacrum; (2) the front of the ilio-lumbar, lumbo-sacral, and anterior sacro-iliac ligaments; (3) the upper and outer half of the venter of the ilium; (4) the origin of the upper tendon of the rectus femoris and the ilio-femoral ligament near the anterior inferior spine of the ilium.

Insertion.—(1) The outer surface of the tendon of the psoas, through which it is attached to the back of the lesser trochanter of the femur; (2) the upper and back part of the shaft of the femur in a line about one inch (2·5 cm.) long leading downwards from the lesser trochanter.

Structure.—Arising by fleshy fibres, the muscle converges in a fan-shape downwards and inwards, and its fibres enter the outer surface of the tendon of the psoas muscle from about two inches (5 cm.) above Poupart's ligament to its insertion. The lowest fibres are also continued, still fleshy, into their insertion on the back part of the shaft of the femur.

Nerve-supply.—From the lumbar plexus (through the second and third lumbar nerves) by the anterior crural nerve, which gives branches to its anterior surface about the middle of its inner border.

Action.—Similar to that of the psoas, as a flexor of the thigh; and acting from the femur as a fixed point, it will draw forwards and flex the pelvis upon the thigh.

Relations.—The iliac fascia in front separates it from the peritoneum and intestines. The profunda femoris artery and several nerves from the lumbar plexus lie upon it. On its inner side lies the psoas. After passing under Poupart's ligament, it is crossed by the sartorius, and behind lie the rectus femoris and the capsule of the hip-joint.

Variations.—A small detached muscle occasionally arises from the anterior inferior spine, and is inserted into the lower part of the anterior intertrochanteric line, or the ilio-femoral ligament.

Psoas Parvus

The **psoas parvus**—a small muscle, only occasionally present, named from its position in the loins and its small size—is fusiform and somewhat flattened.

Origin.—The side of the intervertebral disc between the last thoracic and the first lumbar vertebra and the adjacent borders of the bodies of these vertebræ.

Insertion.—The ilio-pectineal line.

Structure.—Arising fleshy, the fibres converge and are inserted in a somewhat penniform manner into the back and inner surface of a tendon which appears about two inches below the origin of the muscle upon its outer and anterior aspect, and becomes free about the level of the fifth lumbar vertebra. The tendon, a narrow fibrous band, lies upon the inner aspect of the psoas magnus on the brim of the pelvis, and expands at its lower extremity to be attached along the ilio-pectineal line and the ilio-pubal ridge.

Nerve-supply.—By small filaments from the first nerve of the lumbar plexus.

Action.—To flex the pelvis upon the thorax; or, taking the pelvis as a fixed point, it will flex the lower part of the thoracic spine as well as the lumbar spine upon the pelvis. It is a muscle which is well developed in some animals, having for its function the drawing forwards of the lower part of the pelvis, accompanied by the arching of the lumbar spine which is seen when they are running swiftly.

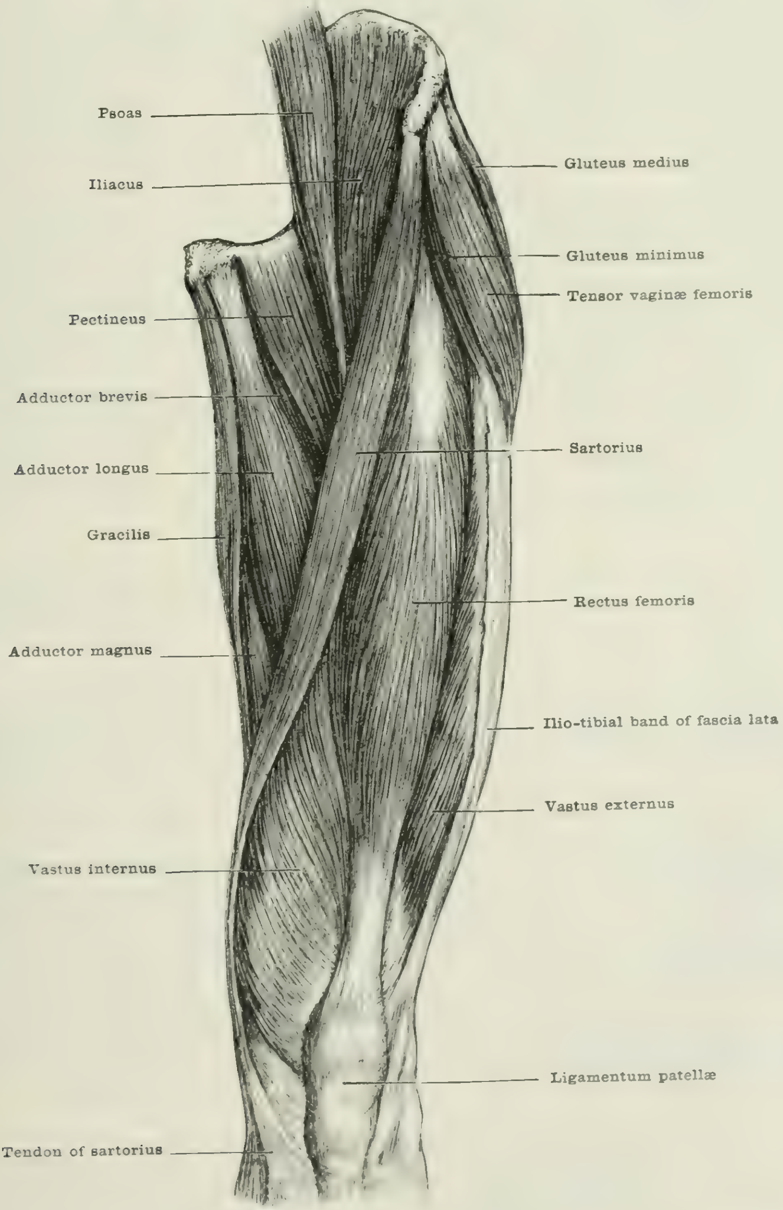
Relations.—In front, the iliac fascia, peritoneum, ligamentum arcuatum internum, intestines, renal vessels, ureter, external iliac vessels, etc. Behind and externally, the psoas magnus.

Iliac Fascia

Investing the abdominal portion of the ilio-psoas is a strong membrane, called the **iliac fascia**, which is attached to the crest of the ilium externally, and internally to the posterior part of the ilio-pectineal line which forms the brim of the pelvis.

Between these attachments it invests the front of the iliacus and psoas muscles. Above, it is continued upwards as the covering of the latter muscle, at the sides of which it is attached to the transverse processes and bodies of the lumbar vertebræ, as well as to the intervertebral discs and the small tendinous arches which bridge the side of the bodies of these vertebræ. At the diaphragm it is thickened, and forms the ligamentum arcuatum internum; near the tips of the transverse processes of the lumbar vertebræ it is attached to the anterior layer of the lumbar fascia (page 408). Below, it joins beneath the outer half of Poupart's ligament with the transversalis fascia, but internal to this it passes downwards into the thigh, forming with the transversalis fascia the sheath of the femoral vessels. Still further

FIG. 287.—MUSCLES OF THE FRONT OF THE THIGH.


Psoas
Iliacus
Gluteus medius
Gluteus minimus
Tensor vaginæ femoris
Pectineus
Adductor brevis
Adductor longus
Sartorius
Gracilis
Rectus femoris
Adductor magnus
Ilio-tibial band of fascia lata
Vastus externus
Vastus internus
Ligamentum patellæ
Tendon of sartorius

inwards, it is continuous with the pubic portion of the fascia lata which invests the pectineus muscle, and it also sends backwards a septum between the psoas and the pectineus which is attached to the ilio-pubal ridge.

3. SARTORIUS

The **sartorius**—named somewhat erroneously from *sartor*, a tailor, because it has been supposed to be the muscle by which the cross-legged sitting posture is produced—is a long, ribbon-shaped muscle slightly fusiform at the two ends.

Origin.—The anterior superior spine of the ilium and the adjacent part of the notch between this process and the anterior inferior spine.

Insertion.—(1) The front part of the inner surface of the tibia, just internal to the tubercle; (2) the upper part of the deep fascia covering the internal surface of the leg.

Structure.—Arising by short tendinous fibres, the fleshy fibres which are the longest in the whole body, run parallel to one another inwards and downwards across the front of the thigh, and after reaching the inner surface of the thigh about the middle, the muscular band runs almost vertically downwards to the back of the internal condyle of the femur. At this point the tendon of insertion makes its appearance as an aponeurosis which covers the deep aspect of the muscle and becomes free from fleshy fibres just below the knee-joint, where it turns forwards and covers the inner surface of the inner tuberosity of the tibia, being separated from it as well as from the tendons of the gracilis and semi-tendinosus by a large bursa. The upper border of this aponeurosis is thick and tendinous and is inserted directly into the bone. The lower part of the aponeurosis, which is of a much more membranous character, is continued downwards and forwards and blends with the deep fascia of the inner side of the leg, of which it is one of the chief constituents.

Nerve-supply.—From the second, third, and fourth branches of the lumbar plexus, by filaments which are usually derived from the middle cutaneous branch of the anterior crural nerve as it pierces the muscle at the junction of its middle and upper thirds.

Action.—(1) To flex the thigh, and at the same time rotate it slightly outwards and abduct it. (2) To flex the knee, and when the knee is in the bent position it will also help in rotating the leg inwards. (3) Being contained in the close-fitting sheath formed by the fascia lata and its deep processes, it will tend when it contracts to draw the soft parts upon the inner surface of the thigh forwards, and so make tense the inner portion of the fascia lata. (4) Acting from below, it will flex the pelvis upon the thigh.

Relations.—In front above lies the fascia lata; internally below lie the fascia lata and internal saphenous vein; beneath lie the rectus femoris, iliacus, pectineus, adductor longus and magnus, vastus internus, and the inner hamstring tendons, the femoral vessels, the anterior crural nerve and its internal saphenous and vastus internus branches.

Variations.—The sartorius is occasionally absent; it may also be divided longitudinally. It may have insertions into the fascia lata, or the ligamentum patellæ. A tendinous intersection sometimes crosses the muscle.

4. PECTINEUS

The **pectineus**—named from *pecten* (= pubes) on account of its origin from that bone—is a quadrilateral sheet.

Origin.—(1) The ilio-pectineal line between the spine of the pubes and the ilio-pubal ridge; (2) the surface in front of the inner end of this line; and (3) the deep surface of the pubic portion of the fascia lata close to its attachment to the ilio-pectineal line.

Insertion.—The back of the femur in a vertical line about two inches (5 cm.) long, beginning just behind the lesser trochanter.

Structure.—The origin is by fleshy and tendinous fibres intermingled. The fibres then run parallel to one another to a tendinous insertion between the iliacus and the adductor brevis. The direction of the surfaces changes so that that which looks forwards above is directed outwards below.

Nerve-supply.—From the lumbar plexus (through the third and fourth lumbar nerves), by a branch of the anterior crural nerve, which, after passing behind the femoral artery and vein, enters the muscle about the middle of its external border. When there is an accessory obturator nerve, it passes over the brim of the pelvis to supply this muscle at the upper part of its anterior surface. Occasionally the muscle receives a branch upon its deep surface from the anterior division of the obturator nerve.

Action.—To flex and at the same time adduct the thigh; as, for example, in crossing the legs, when one thigh is brought forwards and inwards to place it in front of the other thigh. It is also a slight external rotator. Its predominant action is that of flexion, as is indicated by the fact that it receives the same nerve-supply as the sartorius and ilio-psoas. The tendency which it has to adduct during flexion is counteracted by the slight abduction produced by the sartorius. They will together produce the slight external rotation, which is observed during the advance of the leg in walking.

Relations.—In front, the pubic portion of the fascia lata, the femoral and profunda vessels, and at its insertion the psoas and iliacus muscles; behind, the adductor brevis, obturator externus, hip-joint, and obturator nerve.

Variations.—Sometimes a slight blending of the lower fibres of the pectineus with the adductor longus has been observed.

THE GLUTEAL MUSCLES

These are arranged in three layers.

First Layer

The first layer consists of two muscles—the gluteus maximus and the tensor vaginæ femoris.

1. GLUTEUS MAXIMUS

The **gluteus maximus** (figs. 291 and 303)—named from its great size and from the region which it occupies (γλουτός = the buttock)—is a very thick and strong rhomboidal sheet.

Origin.—(1) The posterior fifth of the outer lip of the crest of the ilium, and the outer surface of the ilium between the outer lip of the crest and the superior gluteal line; (2) the lumbar aponeurosis between the posterior superior spine of the ilium and the side of the sacrum; (3) the lateral portion of the posterior surface of the two last pieces of the sacrum; (4) the side of the coccyx; (5) the back of the great sacro-sciatic ligament; (6) in front of its attachment to the ilium a few of its fibres arise from the strong process of the fascia lata which invests the gluteus medius.

Insertion.—(1) The upper part of the strong aponeurosis of the fascia lata, called the *ilio-tibial band*; (2) the gluteal ridge of the femur which leads from the lower border of the greater trochanter to the linea aspera; (3) the adjacent part of the tendinous origin of the vastus externus.

Structure.—Its origin is almost entirely fleshy, a few tendinous fibres only being intermingled between the coarse bundles which run parallel to one another downwards and outwards to the aponeurosis of insertion. The upper half of this aponeurosis passes over the outer surface of the great trochanter to be attached to the upper part of the ilio-tibial band. Lower down the insertion consists of short tendinous fibres, which are not only attached to the rough process of the bone but to the adjacent tendon of the vastus externus, while the more superficial fibres still pass on to be attached to the fascia lata. The whole muscle forms a parallelogram of which the upper and lower parallel sides are formed by the origin and insertion which run in oblique lines downwards and inwards, while the outer and inner borders of the muscle running downwards and outwards form the other two sides of the parallelogram. This muscle is especially remarkable for the large size of the fasciculi in which its fleshy fibres are arranged, and which give the muscle its peculiarly coarse appearance.

There are two well-marked bursæ in connection with the deep surface of this muscle: the one over the tuberosity of the ischium, which is partly covered by the muscle and partly projects from the middle of its lower border in such a way that when the thigh is extended it intervenes between the muscle and the prominence of bone, and when the thigh is flexed it lies between the tuberosity of the ischium and the subcutaneous fat. The second is a large, often multilocular cavity which separates the outer surface of the greater trochanter from the aponeurosis of insertion of the upper part of the muscle. A small bursa is also occasionally found between the lower part of the muscle and the tendon of the vastus externus.

Nerve-supply.—From the sacral plexus (through the fifth lumbar and the first and second sacral nerves), by means of the inferior gluteal branches which enter the deep surface of the muscle close to its inferior and internal border.

Action.—To extend the hip-joint. The upper part of the muscle, passing over the greater trochanter, is placed at a considerable distance from the axis of movement which passes through the centre of the hip-joint. A similar object is obtained by the insertion of the lower fibres of the muscle at some distance down the back of the femur. The whole muscle therefore is able to act as an extensor of the hip-joint with much less mechanical disadvantage than is usual in the body. The gluteus maximus is not used in the movements of extension which require but little muscular power, such as those which draw the thigh backwards in walking; for this purpose the contraction of the hamstring muscles at the back of the thigh is alone employed. Where, however, a greater effort is required, as in ascending a hill or in running and leaping, the gluteus maximus acts with great power.

It has some influence as an external rotator. With respect to abduction and adduction, the action of the muscle is neutral. Acting alone, its upper fibres will assist in the former, and its lower fibres in the latter movement. By means of the ilio-tibial band it makes tense the outer portion of the fascia lata and is able to exert some force in the extension of the knee, especially when that movement is nearly completed. Taking its fixed point from below, the gluteus maximus is a powerful extensor of the pelvis and in some degree of the lower part of the spine, e.g. in rising from the stooping position or where the trunk in a sitting posture is drawn forcibly backwards as in the action of rowing. The influence which it has upon the back by means of its attachment to the lumbar aponeurosis is shown by the great pain which is felt in rising from the stooping position when there is any inflammation of the fasciæ in this region, as in lumbago.

Relations.—Behind, the thick adipose tissue of the buttock and numerous cutaneous nerves; in front, the gluteus medius, pyriformis, gemelli and obturator internus, quadratus femoris, adductor magnus, biceps, semi-tendinosus and semi-membranosus, the gluteal, sciatic and pudic vessels, the great and small sciatic, the pudic and internal obturator nerves, the two sacro-sciatic ligaments, the tuber ischii, and greater trochanter.

Variations.—These are rare. Occasionally a bilaminar arrangement has been observed.

2. TENSOR VAGINÆ FEMORIS

The **tensor vaginæ femoris** (figs. 287 and 303)—named from its function of making tight the fascia lata, or sheath of the thigh (= vagina femoris) is an elongated, four-sided sheet.

Origin.—(1) The front of the outer lip of the crest of the ilium; (2) the upper part of the notch between the anterior superior and the anterior inferior spines of the ilium; (3) the inner surface of the fascia lata, by which it is closely invested.

Insertion.—The fascia lata about one-fourth of the way down the outer side of the thigh.

Structure.—The muscle consists of parallel fleshy fibres which arise by a short tendinous sheet, pass obliquely downwards, outwards, and backwards, and are inserted between two layers of the upper part of the strong aponeurosis of the fascia lata on the outside of the thigh called the *ilio-tibial band*, which also gives attachment to the majority of the fibres of the gluteus maximus. The two muscles meet by their adjacent borders a little below the upper part of the greater trochanter at an angle of about 60°. As they pass upwards, the two divisions of the fascia lata form a strong sheath for the muscle.

Nerve-supply.—Through the fourth and fifth lumbar nerves, and the first sacral, by the terminal branch of the superior gluteal nerve which enters the muscle about the middle of its deep surface near its posterior border.

Action.—To abduct and rotate inwards the thigh, and, taking its fixed point from below, to support the pelvis and to rotate the other side of it forwards. Acting with the gluteus maximus, it will draw upwards the ilio-tibial band, the obliquity of its fibres enabling it to counteract the tendency of that muscle to draw the band backwards. The chief consequence of this traction upon the ilio-tibial band will be to assist in the latter part of the extension of the leg, by the drawing upwards of the external tuberosity of the tibia.

Relations.—Superficially, the fascia lata and the origin of the sartorius; deeply, the deeper layer of the fascia lata, the gluteus medius, the upper part of the rectus femoris and the vastus externus, with some of the branches of the external circumflex artery.

SECOND LAYER

The second layer consists of one muscle—

GLUTEUS MEDIUS

The **gluteus medius** (fig. 288)—named from its size and position, which are intermediate between those of the great and small gluteal muscles—is a strong triangular sheet.

Origin.—(1) The anterior four-fifths of the outer lip of the crest of the ilium; (2) the outer surface of the ilium, bordered above by the middle portion of the outer lip of the crest of the ilium, and in the posterior fifth by the superior gluteal line, below by the middle gluteal line; (3) the strong process of the fascia lata which invests the outer surface of the muscle and separates it behind from the gluteus maximus; (4) the intermuscular septum which intervenes between it and the gluteus minimus just below the anterior superior spine of the ilium.

Insertion.—The well-marked oblique impression extending from the posterior superior to the anterior inferior angle on the outer surface of the greater trochanter.

Structure.—Arising by fleshy and tendinous fibres intermingled, the muscle converges fanwise upon both surfaces of a strong flat tendon which is visible rather higher upon the deep than the outer surface of the muscle. The front part of the muscle is stronger, and it gradually decreases in thickness towards its posterior edge. A bursa is contained between the deep portion of the tendon and the triangular space that lies in front of the impression upon the outer surface of the greater trochanter.

Nerve-supply.—From the fourth and fifth lumbar nerves, and the first sacral nerve by branches of the superior gluteal nerve which enter the deep surface of the muscle near the middle of its posterior border.

Action.—To abduct the hip-joint. It will also by its thicker and stronger anterior fibres rotate the thigh inwards. Its posterior fibres, on the other hand, which are not so strong will tend slightly to rotate the thigh outwards. Acting from below, it tends to support the pelvis upon the femur and to approximate the crest of the ilium to the greater trochanter. This is by far the most important and frequent of its actions. In walking, if it were not for the powerful contraction of the gluteus medius and its associated muscles the gluteus minimus and the tensor vaginæ femoris, the pelvis would not be held firm upon the upper part of the thigh when one leg is upon the ground and the other is being advanced in the forward step. In fast walking the rotatory action of the muscle comes into play, for not only does the gluteus medius of the limb which is resting upon the ground support the pelvis by drawing downwards the crest of the ilium, but, by drawing backwards the front portion of that crest, it throws forwards the opposite side of the pelvis and increases the length of the stride.

Relations.—Superficially, the fascia lata, gluteus maximus, and tensor vaginæ femoris; deeply, the gluteus minimus, superior gluteal vessels and nerve, and the greater trochanter.

Variations.—Sometimes a partially distinct bundle of fibres is inserted into the front of the upper border of the greater trochanter. A slip may be given from the lower border to the pyriformis.

THIRD LAYER

The third layer consists of one muscle—the gluteus minimus—which is continuous with the external rotators which form the next group.

GLUTEUS MINIMUS

The **gluteus minimus** (fig. 290)—named from its position and smaller size—is a thick triangular sheet.

Origin.—(1) The outer surface of the ilium between the middle and inferior gluteal lines; (2) a fibrous septum which intervenes between its fibres and those of the gluteus medius below the anterior superior spine; (3) the front of the capsule of the hip-joint.

Insertion.—The well-marked vertical impression which forms the anterior border of the greater trochanter.

Structure.—From the fleshy origin the fibres converge fanwise upon the deep surface of the tendon which is first seen about the middle of the anterior border, and then covers the lower part of the muscle. By its anterior border this muscle is closely blended with the anterior border of the gluteus medius and with some of the ligaments of the hip-joint. Like the preceding muscle, it is also much thicker and stronger in front.

Nerve-supply.—From the same sources as the preceding by the superior gluteal nerve which distributes filaments to the middle of its outer surface near its posterior border.

Action.—The same as the preceding: viz. to abduct and rotate inwards the hip-joint; and when it takes its fixed point from below, as is most usually the case, to flex the pelvis laterally and at the same time to rotate the other side forwards.

Relations.—Superficially, the gluteus medius, the superior gluteal vessels and nerve; deeply, the capsule of the hip-joint, and posterior head of the rectus femoris.

Variations.—The front part of the muscle may be separate from the rest. It occasionally sends slips to the adjacent muscles.

THE EXTERNAL ROTATORS OF THE THIGH

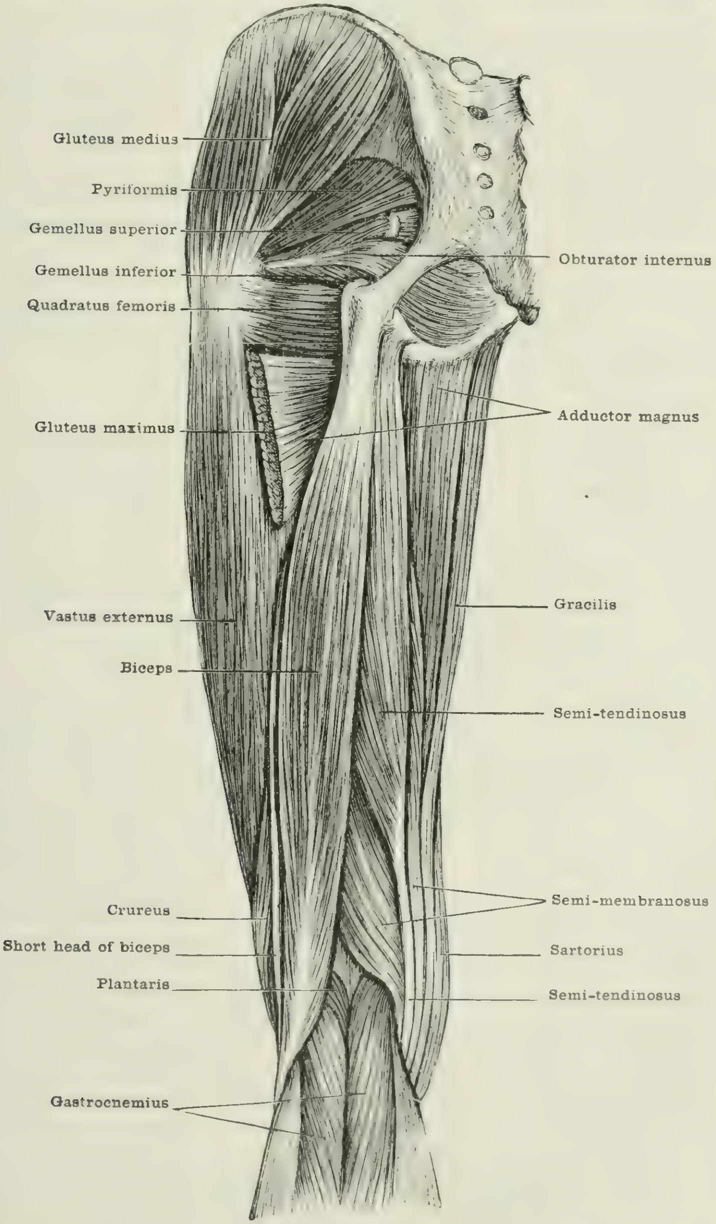
This group consists of six somewhat short muscles, which run transversely from the pelvic bones to the femur, and which follow immediately after the lower fibres of the gluteus minimus—viz. the pyriformis, the obturator internus with the two gemelli, the quadratus femoris, and the obturator externus.

1. PYRIFORMIS

The **pyriformis**—named from its pear shape (*pirus* = pear)—is a thick triangular sheet.

Origin.—(1) The side of the front of the sacrum between and to the outer side of the first, second, third, and fourth foramina; (2) the deep surface of the great sacro-sciatic ligament; (3) the posterior border of the hip bone at the upper part of the great sacro-sciatic notch.

FIG. 288.—THE EXTERNAL ROTATORS AND THE HAMSTRING MUSCLES.


Gluteus medius
Pyriformis
Gemellus superior
Gemellus inferior
Quadratus femoris
Gluteus maximus
Vastus externus
Biceps
Crureus
Short head of biceps
Plantaris
Gastrocnemius
Obturator internus
Adductor magnus
Gracilis
Semi-tendinosus
Semi-membranosus
Sartorius
Semi-tendinosus

Insertion.—A small facet upon the front and inner aspect of the upper border of the greater trochanter.

Structure.—The greater part of the muscle arises by three fleshy slips on the ridges of bone between, and external to, the anterior sacral foramina. From this origin, which receives accessory slips of small size from the great sacro-sciatic ligament and the upper portion of the great sacro-sciatic notch, the fibres converge as they pass transversely outwards and somewhat backwards through the great sacro-sciatic foramen. The tendon is first visible upon the deep aspect of the muscle, and it becomes free near the posterior border of the greater trochanter. Shortly before its insertion it is closely blended with the tendon of the obturator internus muscle.

Nerve-supply.—From the sacral plexus by small branches which pass from the second sacral nerve into the anterior surface of the muscle near its origin.

Action.—To rotate the thigh outwards. When the thigh is fixed, it will rotate the pelvis so that the face is turned to the opposite side; if the thigh be flexed, the pyriformis will abduct it.

Relations.—In front, the sacral plexus and rectum, the back of the hip-joint, and some of the branches of the internal iliac artery; behind, the gluteus maximus; above, the gluteus medius and minimus, with the superior gluteal vessels and nerve; below, the coccygeus, the lesser sacro-sciatic ligament and gemellus superior, the sciatic and pudic vessels, and most of the branches from the sacral plexus.

Variations.—The pyriformis may be absent. It is often divided by a part of the great sciatic nerve into two muscles, and sometimes into three. It may be more or less blended with the gluteus medius or minimus above, and the superior gemellus below.

2, 3, AND 4. OBTURATOR INTERNUS AND GEMELLI

The **obturator internus** and **gemelli** form really a single muscle, the greater part of which arises inside the pelvis; while the gemelli form two accessory slips which join it from the margin of that cavity.

The **obturator internus**—named from the fact that it arises from the membrane which closes up the obturator foramen, and from its position within the pelvis—is a somewhat triangular sheet, or rather, perhaps, it should be described as the sector of a circle, for its origin within the pelvis is bounded by a curved line like a part of the circumference of a circle.

Origin.—The whole of the interior of that part of the pelvis which is formed by the innominate bone: viz. (1) The back of the body and descending ramus of the os pubis, and of the ascending ramus of the ischium; (2) the whole of the inner surface of the obturator membrane; (3) the broad surface of bone behind the foramen, corresponding to the acetabulum on the exterior; (4) the outer surface of the pelvic and obturator fasciæ. These extend from the ilio-pectineal line above to the great sacro-sciatic foramen behind, and to the spine and tuberosity of the ischium below.

Insertion.—The inner aspect of the upper border of the greater trochanter at the point where it unites with the upper border of the neck of the femur.

Structure.—The muscle arises fleshy from the whole of the interior of the pouch-like cavity formed by the pelvic and obturator fasciæ internally and the bony wall of the pelvis externally, and opening backwards and downwards at the lesser sacro-sciatic foramen. From this extensive origin the fibres converge downwards and backwards upon a broad tendinous expansion which begins about one inch (2·5 cm.) above the lesser sacro-sciatic foramen upon the outer surface of the muscle. This expansion is corrugated into four or five folds, which are separated from the cartilaginous lining of the lesser sacro-sciatic notch by a bursal cavity which allows of the smooth play of the tendon upon the bone. This cartilage presents corresponding grooves for the folds of the tendon. After passing through this foramen the tendon changes its course, and is directed transversely outwards and forwards to its insertion. The fleshy fibres extend upon the inner, which has now become its posterior surface for about half the distance from the notch to the facet upon the greater trochanter. For a short distance before its insertion it is intimately connected with the tendon of the pyriformis.

Nerve-supply.—From the first and second sacral nerves of the sacral plexus by a special nerve which, after passing through the lesser sacro-sciatic notch, is distributed to the muscle, entering its inner surface near its upper border and close to the lesser sacro-sciatic foramen.

The **gemellus superior**—named from *gemellus* = a twin, because it is the upper of the two twin muscles which nearly surround the tendon of the obturator internus at its point of emergence from the pelvis—is a somewhat triangular sheet curved upon itself to embrace the rounded tendon of the obturator internus.

Origin.—(1) The outer surface of the spine of the ischium; (2) the upper half of the outer edge of the lesser sacro-sciatic notch.

Insertion.—The upper border and the anterior surface of the obturator internus tendon, a short distance from its insertion.

Structure.—Arising fleshy from the bone at the margin of the lesser sacro-sciatic foramen, the muscular fibres converge slightly and form a sheet which is curved upon itself so as to fit round the upper border and anterior aspect of the obturator internus tendon, with which, after a course of about two inches (5 cm.) in length, it blends.

Nerve-supply.—The first and second nerves of the sacral plexus by a small special branch which enters the muscle at the upper part of its anterior surface near its origin.

The **gemellus inferior**—the lower of these twin muscles—is also triangular in shape, but is somewhat broader and stouter than its fellow.

Origin.—(1) The upper part of the inner border of the tuber ischii: and (2) the lower half of the outer edge of the lesser sacro-sciatic notch.

Insertion.—The lower border and anterior surface of the tendon of the obturator internus, a short distance from its attachment to the greater trochanter.

Structure.—Its fibres, arising fleshy from the lower half of the outer border of the lesser sacro-sciatic notch, converge and form a sheet which wraps round the lower part of the anterior surface of the tendon of the obturator internus. The two gemelli therefore together form an envelope which embraces the whole of the tendon of the obturator internus after its emergence from the pelvis, with the exception of a part of its posterior surface.

Nerve-supply.—From the sacral plexus (through the fifth lumbar and first sacral nerves), by filaments from the special nerve to this muscle and the quadratus femoris, which enter the upper part of its anterior surface near its origin.

Action.—The obturator internus with its two satellites, the gemelli, powerfully rotates the femur outwards. It should be observed that, although the fibres are mostly directed backwards and downwards within the pelvis, the action of the muscle is really determined by the outward and slightly forward direction of the tendon outside the pelvis; and the notch upon the bone plays the part of a pulley in changing the direction of the force.

Besides its action as an external rotator, the muscle will be able to assist abduction when the thigh is bent through a right angle.

Relations.—The obturator internus in the pelvis is in contact externally with the innominate bone and obturator membrane; above, with the obturator artery and nerve; internally, with the pelvic and obturator fasciæ, the levator ani, the pelvic viscera, and the pudic vessels and nerve.

Outside the pelvis, the tendon of the obturator internus, with the gemelli, is in contact, in front with the capsule of the hip-joint and the tendon of the obturator externus; behind, with the gluteus maximus, great sacro-sciatic ligament, the sciatic vessels and nerves; above, with the pyriformis and the structures which come out of the pelvis below it; below, with the quadratus femoris and a branch of the internal circumflex artery.

Variations.—One or other of the gemelli may be absent, but more frequently the upper one. An accessory slip to the obturator internus has been observed coming from the third piece of the sacrum.

5. QUADRATUS FEMORIS

The **quadratus femoris**—named from its square shape and its insertion into the femur—is a four-sided sheet.

Origin.—The upper part of the outer border of the tuber ischii.

Insertion.—The vertical ridge which begins just above the middle of the posterior intertrochanteric line of the femur, and is called the 'linea quadrati.'

Structure.—Its fibres are fleshy and run parallel to one another almost horizontally outwards and slightly forwards.

Nerve-supply.—From the sacral plexus (through the fifth lumbar and first sacral nerve) by a special branch which, after furnishing filaments to the inferior gemellus, enters the muscle near the upper part of its anterior surface close to its origin.

Action.—It approximates the posterior border of the greater trochanter to the tuber ischii, and so assists powerfully in the external rotation of the femur.

Relations.—Behind, the gluteus maximus and the two sciatic nerves; in front, the obturator externus and the termination of the internal circumflex artery. Above is the inferior gemellus, and below the adductor magnus.

Variations.—This muscle is not unfrequently absent.

6. OBTURATOR EXTERNUS

The **obturator externus** is a strong external rotator of the thigh, but it is also an adductor, and on account of its nerve-supply and position it is better described in that group of muscles.

THE ADDUCTORS

The **adductor muscles** form a distinct group on the inner side of the thigh, and are all supplied by the obturator nerve with the exception of a small part of the adductor magnus. They consist of the adductor longus, adductor brevis, adductor magnus, gracilis, and obturator externus.

1. ADDUCTOR LONGUS

The **adductor longus**—so named from its action and its length compared with that of its immediate neighbour—is a thick triangular sheet.

Origin.—A rounded impression on the front of the body of the os pubis immediately below the crest and angle.

Insertion.—(1) The lower two-thirds of the inner lip of the linea aspera (in the middle third of the thigh); and (2) the adjacent internal intermuscular septum.

Structure.—Arising by a strong rounded tendon, which extends about two inches (5 cm.) downwards upon the inner border of the muscle, the fleshy fibres diverge in a fan-shaped expansion, and are inserted by short tendinous fibres which blend behind with those of the adductor brevis and adductor magnus.

Nerve-supply.—From the third and fourth nerves of the lumbar plexus, by branches from the anterior division of the obturator nerve which enter the muscle on the upper part of its posterior surface rather below its middle.

Action.—To adduct and flex the femur, and at the same time to rotate it outwards.

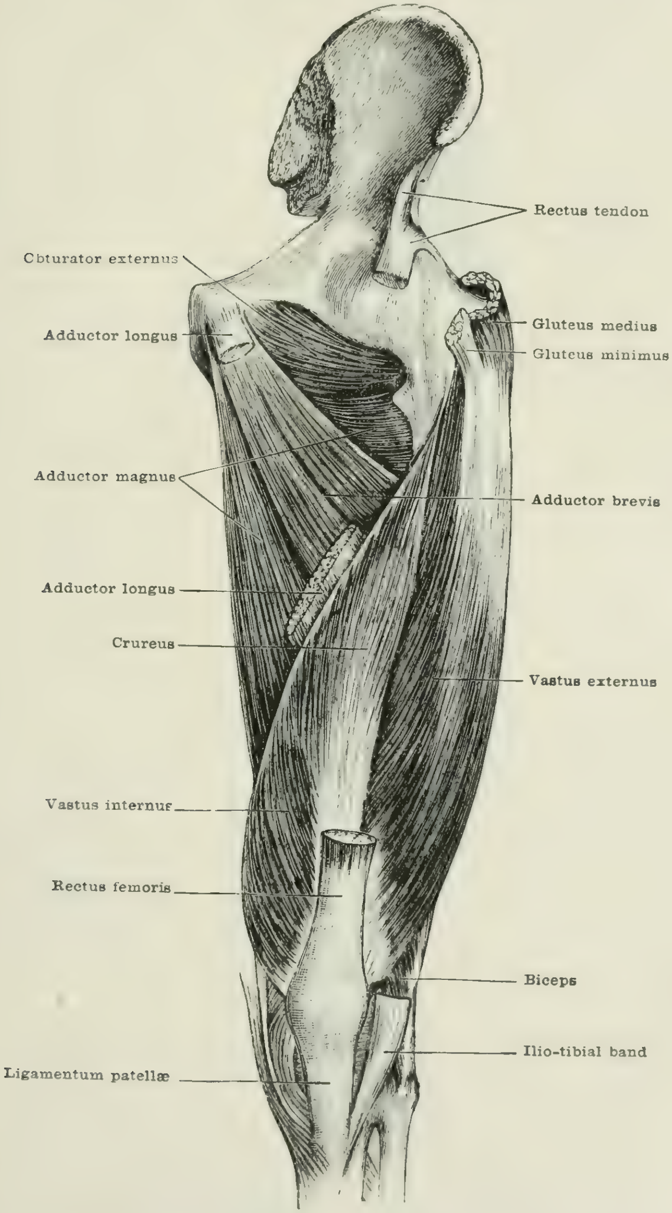
Relations.—In front, the fascia lata, sartorius, vastus internus, and superficial femoral vessels; behind, the adductor brevis and magnus, the profunda vessels, and the obturator nerve; its upper border touches the pectineus.

Variations.—The adductor longus may arise by two heads, the outer being attached to the crest of the pubes, and separate from the ordinary head which arises below the angle. Occasionally the muscle is divided by the passage of vessels into an upper and a lower portion.

2. ADDUCTOR BREVIS

The **adductor brevis**—named from its action and its size as compared with the preceding muscle—is a thick quadrilateral sheet.

FIG. 289.—THE DEEP MUSCLES OF THE FRONT OF THE THIGH.


Rectus tendon
Obturator externus
Adductor longus
Gluteus medius
Gluteus minimus
Adductor magnus
Adductor brevis
Adductor longus
Crureus
Vastus externus
Vastus internus
Rectus femoris
Biceps
Ilio-tibial band
Ligamentum patellæ

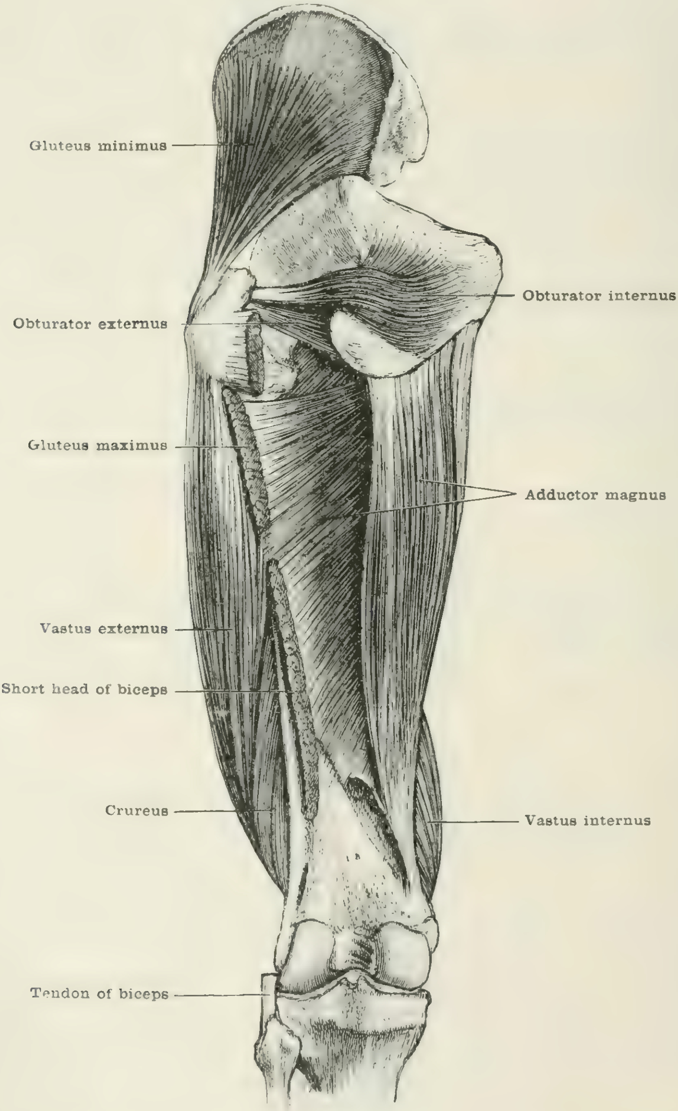
Origin.—The body and the descending ramus of the os pubis, below, and somewhat external to, the origin of the adductor longus.

Insertion.—The inner lip of the linea aspera in its upper half, extending from just below the lesser trochanter to about the middle of the back of the femur.

Structure.—Arising by short tendinous fibres, the muscle diverges into a fan-shaped fleshy expansion, which ends in short tendinous fibres blending with those of the adductor longus and adductor magnus.

Nerve-supply.—From the third and fourth nerves of the lumbar plexus by the superficial branch of the obturator nerve, which sends filaments to the anterior surface of the muscle near the lower part of its upper border. Sometimes, however, it derives its nerve-supply from the deeper division of the obturator nerve, and in that case the nerves enter the muscle from behind.

FIG. 290.—THE DEEP MUSCLES OF THE BACK OF THE THIGH.


Gluteus minimus
Obturator internus
Obturator externus
Gluteus maximus
Adductor magnus
Vastus externus
Short head of biceps
Crureus
Vastus internus
Tendon of biceps

Action.—Like the preceding, it is an adductor and rotator outwards of the femur, but it will not assist so powerfully in flexion.

Relations.—In front, the pectineus, adductor longus, the profunda vessels, and superficial branch of the obturator nerve; behind, the obturator externus and adductor magnus, and the deep branch of the obturator nerve.

Variations.—It is sometimes divided into an upper and a lower portion. Occasionally it joins above with the obturator externus.

3. ADDUCTOR MAGNUS

The **adductor magnus**—named from its action and its great size—is a thick fan-shaped sheet, forming a right-angled triangle, the right angle of which is contained between the side corresponding to the insertion of the muscle at the back of the femur and the side formed by the free upper border of the muscle.

Origin.—(1) The lower part of the outer border of the tuber ischii; (2) the outer surface of the ascending ramus of the ischium near its inner border; (3) the front of the outer surface of the descending ramus of the pubes.

Insertion.—(1) The back of the femur, in a line beginning at the lower extremity of the linea quadrati, and extending along the inner border of the gluteal ridge and the middle of the linea aspera down to its bifurcation; (2) the adductor tubercle on the upper and posterior part of the internal condyle; (3) the lower part of the internal intermuscular septum.

Structure.—Its origin and insertion are by short tendinous fibres, with the exception of the insertion of the bundle of fibres which passes from the tuber ischii to the adductor tubercle. These arise by a long tendon above, and again become tendinous three or four inches (7 to 10 cm.) above the knee-joint, so as to form a long and conspicuous tendon on the lower part of the inner border of the muscle. Between this part of the insertion of the muscle and the linea aspera, the fibres are attached to the back of the internal intermuscular septum and to a tendinous arch which allows of the passage of the superficial femoral artery and vein from Hunter's canal into the upper part of the popliteal space. Between the origin and insertion the fibres diverge; the anterior fibres of origin passing horizontally outwards to their insertion into the upper part of the back of the femur, while the fibres which arise behind pass vertically downwards from the tuber ischii to the internal condyle. Moreover, the muscle is twisted upon itself so that the surface which above looks inwards and rather backwards is directed forwards below. A deep longitudinal groove is thus formed upon the upper part of the back of the muscle, in which lie the hamstring muscles and the great sciatic nerve. The upper part of the muscle, which arises in front, and is inserted into the inner border of the gluteal ridge, forms a triangular sheet, usually separate from the rest, and sometimes described as a distinct muscle, the adductor minimus.

In addition to the opening for the superficial femoral vessels, the muscle is pierced close to the bone by the perforating arteries and the terminal branch of the profunda femoris. Upon its anterior surface it receives a membranous expansion from the vastus internus, which passes inwards beneath the sartorius to the adductor longus and magnus, forming the anterior wall of a sort of tunnel which contains the superficial femoral vessels in the middle third of the thigh, and is called Hunter's canal.

Nerve-supply.—Chiefly from the third and fourth nerves of the lumbar plexus by the deep division of the obturator nerve which supplies the muscle upon the outer part of its anterior surface. The lower fibres of the muscle, however, are supplied upon their posterior surface by the great sciatic nerve, a branch of the sacral plexus.

Action.—This muscle is the most powerful of the adductors. The upper three fourths of its fibres will also rotate outwards the femur, while that part of the muscle which arises from the tuber ischii and is inserted into the inner condyle will tend slightly to rotate the thigh inwards, and will at the same time extend as well as adduct the thigh.

Duchenne suggests that this is the part of the muscle which equestrians should especially develop. Otherwise the adduction of the thighs in gripping the saddle is apt to throw out the toes, which is ungainly, and, if the rider have spurs on, may lead to unpleasant consequences.

Relations.—In front lie the adductor brevis and longus, and lower down the vastus internus. Behind are the hamstring muscles, the gluteus maximus, and the great sciatic nerve. At its upper border are the quadratus femoris and obturator externus. Along its inner border lie the gracilis and part of the sartorius. It is also in relation with the superficial and deep femoral vessels, and the obturator nerve.

Variations.—The posterior part of the muscle may form a distinct slip. Accessory bundles from the semi-membranosus or biceps may join the lower tendon. The upper border of the muscle may be blended with the quadratus femoris.

4. GRACILIS

The **gracilis**—named from its form (*gracilis* = slender)—is long and ribbon-shaped.

Origin.—The inner edge of the anterior surface of the body and descending ramus of the os pubis from about the middle of the symphysis to the junction of the rami of the pubes and ischium.

Insertion.—The inner surface of the tibia below its inner tuberosity, behind the insertion of the sartorius.

Structure.—Arising by a broad and thin aponeurosis, the muscular fibres pass down the inner surface of the thigh almost parallel to one another, but with a slight convergence, so that the muscle in descending increases in thickness as it diminishes in breadth. About two inches (5 cm.) above the inner condyle it becomes a rounded flattened tendon. This runs behind the inner condyle, and, after forming one of the two hamstring tendons which can be easily felt at the inner border of the popliteal space, it passes forwards to be inserted in a slightly expanded form below the inner tuberosity. A few fibres pass from its lower border to the deep fascia of the leg.

Nerve-supply.—From the third and fourth nerves of the lumbar plexus by a branch from the superficial division of the obturator nerve which enters the deep surface of the muscle above its middle.

Action.—To adduct the thigh and flex the knee. When the knee is flexed, it will help in rotating the leg inwards.

Relations.—It lies superficially in its whole course under cover of the fascia lata. Upon its deep surface lie the adductor brevis and magnus, and lower down the semi-membranosus muscle. It has in front of it the sartorius muscle which overlaps it slightly at the lower part of the thigh, and behind it is the tendon of the semi-tendinosus. The internal lateral ligament of the knee and a large bursa lie beneath its tendon.

5. OBTURATOR EXTERNUS

The **obturator externus** (figs. 286, 289, and 290)—named from its attachment to the obturator membrane upon its outer surface—is a triangular sheet.

Origin.—(1) The inner half of the anterior surface of the obturator membrane; (2) the descending ramus of the os pubis immediately internal to the foramen; (3) the ascending ramus of the ischium internal to the foramen.

Insertion.—The digital fossa upon the inner surface of the great trochanter.

Structure.—It is a fan-shaped triangular muscle which arises fleshy from the adjacent surfaces of bone and membrane, in a curve which is convex forwards and inwards. From this wide origin the fibres converge outwards, and end below the acetabulum in a rounded tendon which passes behind and in close contact with the capsule of the joint to its insertion in the digital fossa. Not unfrequently a small portion of the muscle is separated at its upper border from the rest by one or both of the divisions of the obturator nerve.

Nerve-supply.—From the third and fourth nerves of the lumbar plexus by the deep division of the obturator nerve which distributes filaments to the deep surface of the muscle as it is passing through it.

Action.—To adduct and rotate outwards the thigh.

Relations.—Behind, the obturator vessels, and at its insertion the quadratus femoris; in front, the psoas muscle, the pectineus, and adductor brevis; above, the obturator nerve, one or both branches of which perforate it, and more externally the capsule of the hip-joint.

THE HAMSTRING MUSCLES

The **hamstring muscles** form a group at the back of the thigh, separated by intermuscular septa from the vastus externus on the outer, and the adductor magnus on the inner side. They consist of the biceps, semi-tendinosus and semi-membranosus, and are supplied by the great sciatic nerve. Like the gluteus maximus their action is to extend the hip.

1. BICEPS FEMORIS

The **biceps femoris** (figs. 288 and 290)—named from its two heads—consists of two parts: the longer head being somewhat fusiform, and the shorter a triangular sheet.

Origin.—The **long head** from (1) the lower and inner facet at the back of the tuber ischii by a tendon common to it and the semi-tendinosus; (2) the lower part of the great sacro-sciatic ligament. The **short head** from (1) the outer lip of the linea aspera from a point just above the middle of the bone down to the bifurcation; (2) the upper two-thirds of the outer condylar ridge; (3) the external intermuscular septum.

Insertion.—(1) A fossa below and in front of the styloid process of the head of the fibula; (2) the deep fascia covering the peronei muscles; (3) the outer tuberosity of the tibia.

Structure.—The origin of the long head is by a short tendon which is continued down to the middle of the thigh by a septum which divides this muscle from the semi-tendinosus. From this tendon and the outer surface of the septum the muscular fibres arise in penniform fashion and form a fusiform belly, which receives at the junction of the middle and lower thirds of the thigh the thick sheet of muscular fibres derived from the short outer head. The tendon commences upon the posterior surface of the muscle near its outer border about the middle of the thigh. At the back of the external condyle the fleshy fibres cease. The rounded tendon here widens into a thick aponeurosis, which embraces the anterior portion of the external lateral ligament at the point of its insertion into the outer and anterior facet of the head of the fibula. Between this tendon and the external lateral ligament is a bursa. From the borders of the tendon at this point a thinner aponeurosis is given off to the outer tuberosity of the tibia in front and the deep fascia of the leg behind.

Nerve-supply.—From the first, second and third nerves of the sacral plexus by the great sciatic nerve which sends branches to the anterior and inner surfaces of the muscle about the middle of the thigh. The short head of the biceps receives its supply from the external popliteal nerve.

Action.—To extend the hip and flex the knee. Its shorter head acts upon the knee only. When the knee is flexed, both heads will unite in rotating the leg outwards. When the knee is extended, the long head will have a slight influence in rotating the hip outwards. Acting from below, the long head will assist in raising the body from the stooping position.

Relations.—Behind, the gluteus maximus, the plantaris, the outer head of the gastrocnemius, gluteus maximus, fascia lata, and the small sciatic nerve. In front, the tendon of the semi-membranosus, the adductor magnus, and the great sciatic nerve. Upon its inner border lie the semi-tendinosus, semi-membranosus, and the external popliteal nerve. Beneath the lower tendon is a bursa which separates it from the external lateral ligament of the knee-joint.

Variations.—The short head of the biceps may be absent. Accessory heads may be derived from the tuber ischii, the upper part of the linea aspera, the fascia lata, or the inner surface of the tendon of insertion of the gluteus maximus. It may send a slip to the gastrocnemius.

2. SEMI-TENDINOSUS

The **semi-tendinosus** (fig. 288)—named from the long tendon which forms the lower half of the muscle—is fusiform and somewhat flattened.

Origin.—By a tendon which is common to it and the preceding muscle, from the lower and inner of the facets at the back of the tuber ischii.

Insertion.—(1) The upper part of the inner surface of the tibia below and behind the insertion of the gracilis; (2) the deep fascia of the inner side of the leg.

Structure.—The rounded and somewhat flattened tendon of about two inches (5 cm.) in length is succeeded by a fusiform mass of muscular fibres, which end just below the middle of the thigh in a flattened cylindrical tendon. This runs directly downwards along the inner side of the popliteal space, where it can easily be felt beneath the skin, behind and external to the tendon of the gracilis, in company with which it passes downwards and forwards behind the internal condyle to its insertion below the inner tuberosity. From the lower border of the flattened tendon an aponeurosis passes downwards to the deep fascia of the leg. The fleshy part of the muscle is crossed about its middle by a thin tendinous intersection running downwards and outwards.

Nerve-supply.—From the first, second, and third nerves of the sacral plexus by means of branches from the great sciatic nerve which enter the outer part of the deep surface of the muscle two or three inches (about 6 cm.) below the tuber ischii.

Action.—To extend the hip and flex the knee, and when the knee is flexed to rotate the leg inwards. Acting from below, it lifts up the body from the stooping position.

Relations.—Behind, the gluteus maximus and fascia lata; on its outer side the biceps; in front, the semi-membranosus, adductor magnus, and near the knee the gracilis, sartorius, and the inner head of the gastrocnemius. The large bursa beneath the sartorius tendon also wraps round the lower part of the tendon of the semi-tendinosus, and separates it from the internal lateral ligament of the knee-joint.

3. SEMI-MEMBRANOSUS

The **semi-membranosus** (fig. 288)—named from the broad membrane-like aponeurosis which forms the upper third of the muscle—is strong, flattened, and fusiform.

Origin.—The anterior and upper of the facets upon the back of the tuber ischii.

Insertion.—(1) The lower part of the posterior extremity of the groove upon the back and inner side of the inner tuberosity of the tibia; (2) by a band of fibres which pass upwards and outwards to the upper and back part of the external condyle of the femur, and blend with the posterior ligament of the knee-joint; (3) by a broad expansion which, passing downwards and outwards from its insertion into the inner tuberosity to the oblique line at the back of the tibia, forms the aponeurosis which invests the posterior surface of the popliteus; (4) a few fibres pass downwards and forwards from the lower border of its tibial insertion to blend with the internal lateral ligament.

Structure.—The upper part of the muscle consists of a strong flat tendon about three-quarters of an inch (nearly 2 cm.) broad, which extends along the outer border of the muscle to the middle of the thigh. The tendon of insertion is not quite so broad but much thicker, and reaches upon the inner border of the muscle also as high as the middle of the thigh. Between these two tendons the muscular fibres which are comparatively short pass downwards and inwards, beginning upon the upper tendon about four inches (10 cm.) below the tuber ischii, and ending upon the lower tendon close to the upper part of the inner condyle. The muscle has therefore a very distinctly penniform arrangement, but it is peculiar in this respect that the fleshy fibres are at each extremity attached to a tendon, and are not, as is usually the case, at one extremity attached to the bone. It is also unusual for a muscle to have so long a tendon at its proximal end. One effect of this arrangement is to allow of the free action of the long head of the biceps which crosses over this part of the semi-membranosus. Otherwise the swelling of the fibres of the biceps during contraction might have pressed upon and interfered with the action of the semi-membranosus, which usually contracts at the same time.

Nerve-supply.—From the first, second, and third nerves which enter into the formation of the sacral plexus through the great sciatic nerve which sends branches to the deep surface of the muscle about the middle of the thigh.

Action.—To strongly extend the hip and to flex the knee. When the knee is flexed it will also assist in the internal rotation of the leg, but with less mechanical advantage than the semi-tendinosus and gracilis, as its line of action is so near to the axis of movement.

Like most penniform muscles, the semi-membranosus is very powerful, as is shown by the thickness of its tendons. This strength is necessitated by the fact that its line of action is so much nearer to the axis of movement both in flexion and rotation inwards of the knee. Like the other muscles which arise from the tuber ischii, it will co-operate powerfully in raising the body from the stooping position, this prominence of bone forming the short arm of the lever by which the trunk is raised. This group of muscles affords a good example of the peculiar action obtained by long muscles passing over two joints. If all three muscles were to remain passive, like so many ligaments, it is obvious that on flexion of the hip-joint by means of the ilio-psoas and other muscles, the hamstrings would ensure the simultaneous flexion of the knee; or, again, on extension of the knee by the action of the powerful muscles of the front of the thigh, the hamstrings would produce a corresponding extension of the hip-joint. Seeing, however, that these hamstrings are not passive, but that they contract powerfully at the same time in many of these movements, it follows that in flexion of the hip in such movements as those of running, the knee is at the same time flexed with increased rapidity; and again, when the knees are extended by the powerful contraction of the quadriceps muscle, the simultaneous action of the hamstring muscles will produce a still more rapid elevation of the trunk.

Relations of the semi-membranosus.—Behind, the gluteus maximus, biceps, and semi-tendinosus; in front, the adductor magnus, posterior ligament of knee, and the popliteus. Along its outer border lies the great sciatic nerve, and just before its insertion the inner head of the gastrocnemius hooks round this border, being separated from it by a bursa which communicates with the knee-joint. There is also usually a small bursa between its tendon and the back of the inner tuberosity of the tibia.

Variations.—The semi-membranosus has occasionally been deficient, or only represented by a thin musculo-tendinous band. It has also been found double.

ANTERIOR MUSCLES OF THE THIGH

This group consists of the sartorius and the quadriceps extensor.

1. SARTORIUS

This muscle has already been described (see page 350).

2. QUADRICEPS EXTENSOR

The **quadriceps extensor** (figs. 287 and 289), as its name implies, consists of four heads. Of these, one, the rectus, arises from the innominate bone; and the three others, the vastus externus, vastus internus, and crureus, from the femur; while the common tendon is inserted into the upper border and sides of the patella.

(*a*) Rectus Femoris

The **rectus femoris**—named from its long straight course—is strong, fusiform, and flattened from before backwards; it arises by an anterior and a posterior head.

Origin.—*Anterior head*, from the front of the anterior inferior spine of the ilium; *posterior head*, from the upper surface of the rim of the acetabulum just external to the attachment of the capsular ligament.

Insertion.—The front of the upper border of the patella.

Structure.—This muscle consists of two strong tendinous expansions joined by fleshy fibres. The upper expansion is formed above by the union of the two tendinous heads in a small arch, which is intimately connected with the capsule of the hip-joint. From this arch the tendinous expansion descends upon the front of the muscle as far as the middle of the thigh, getting thinner and narrower as it descends. The tendon of insertion begins upon the back of the muscle also about the middle of the thigh, and soon expands into a broad aponeurosis which covers the back of the muscle at its lower end; about three inches (7·5 cm.) above the patella, it becomes free of muscular fibres, and forms a strong tendinous band which is inserted into the upper border of the patella. The fleshy fibres pass from the back and sides of the upper expansion to the front and sides of the tendon of insertion. Seen from the front, these fleshy fibres appear to diverge on both sides from the upper expansion, and, after passing round the border of the muscle, they converge upon the tendon of insertion so as to give the muscle a bipenniform appearance.

Nerve-supply.—From the lumbar plexus (through the second, third, and fourth lumbar nerves), by the anterior crural nerve which sends filaments to the posterior aspect of the muscle in the upper half of its course.

Action.—To assist in the powerful extension of the knee by the quadriceps. It will also help in flexion of the hip; and it will be a powerful agent in preventing dislocation of the head of the femur. When the hip-joint is flexed, the muscle will act chiefly from its posterior head; but when the hip is extended, the anterior head of the muscle will act with more power.

Relations.—In front lie the sartorius, tensor vaginæ femoris, and the fascia lata; behind, it lies on the hip-joint and the crureus muscle; upon its inner border above is the iliacus; and outside it lie the gluteus medius and minimus.

(*b*) Vastus Externus

The **vastus externus**—named from its great size and its position upon the outer surface of the thigh—is a thick rhomboidal sheet.

Origin.—(1) The upper half of the anterior intertrochanteric line and the front of the upper part of the femur along the anterior border of the greater trochanter; (2) a horizontal line which forms the lower border of the greater trochanter; (3) the outer lip of the gluteal ridge; (4) the upper half of the outer lip of the linea aspera and the adjacent portion of the shaft of the femur for about one-sixth of an inch (4 mm.); (5) the external intermuscular septum in the neighbourhood of its attachment to the linea aspera.

Insertion.—(1) The outer half of the upper border of the patella, behind the preceding tendon, with which it also blends; (2) the upper third of the outer border of the patella; (3) by an aponeurosis which is inserted partly into the front of the external tuberosity of the tibia, partly into the deep fascia of the leg.

Structure.—Arising partly directly from the bone, and partly by a strong aponeurosis which covers the outer surface of the muscle in its upper two-thirds, the fleshy fibres run parallel to one another downwards, forwards, and inwards, at the same time curving slightly as they pass over the rounded mass formed by the crureus muscle. The aponeurosis of insertion lies upon the inner surface of the muscle and receives fleshy fibres to within one inch (2·5 cm.) of its insertion into the patella and its blending with the other tendons of the quadriceps muscle. Upon its anterior surface it unites with the tendon of the rectus muscle, and upon its posterior surface is received a part of the insertion of the crureus.

Nerve-supply.—From the anterior crural (through the second, third, and fourth lumbar nerves), by several branches which enter the internal surface of the muscle in the upper third of the thigh.

Action and relations.—These will be considered with those of the two following muscles.

(*c, d*) VASTUS INTERNUS AND CRUREUS

The **vastus internus** and **crureus** are so closely blended that it is better to describe their origins together before mentioning the way in which they may be separated. They have received their names, the former from its size and position; the latter from its intimate connexion with the whole of the front of the thigh bone, the term 'crus' being often used synonymously with the femur. The blended muscle is a somewhat fusiform sheet which is so curved laterally as to form a cylinder embracing the whole of the front and sides of the shaft of the femur.

Origin.—(1) The outer lip of the lower half of the linea aspera and its external bifurcation, together with the adjacent external intermuscular septum; (2) the lower part of the anterior intertrochanteric line and the spiral line of the femur; (3) the inner lip of the whole length of the linea aspera and its internal bifurcation, together with the adjacent part of the internal intermuscular septum, and the front of the tendon of the adductor magnus; (4) the greater part of the front and sides of the femur within the limits formed by the three preceding attachments and the origin of the vastus externus.

Insertion.—(1) The front aspect of the upper border of the patella immediately behind the insertion of the rectus femoris tendon; (2) the upper half of the inner border of the patella; (3) by a strong aponeurosis into the front of the inner tuberosity of the tibia and into the adjacent deep fascia of the leg.

Structure.—The fibres of this large muscle arise fleshy from the surface of the femur and converge, from the outer side downwards, forwards, and inwards; from the front directly downwards; from the inner side downwards, forwards, and outwards, upon the back and sides of a strong aponeurosis which covers the front of the muscle from about the middle of the thigh downwards. The fibres which arise from the tendon of the adductor magnus and the adjacent intermuscular septum form the lowest part of the thick muscular belly of the vastus internus, and are directed almost transversely outwards to get to their insertion upon the inner border of the patella. The substance of the muscle is arranged in layers which wrap round the front and sides of the femur; and between the attachment of these layers to the bone, longitudinal strips of bone may be found upon dissection without any muscular attachment. The deepest of these layers in the lower fourth of the thigh forms a separate sheet of muscular fibre, sometimes called the **subcrureus**, which is inserted into the upper reflexion of the synovial membrane of the knee-joint. Beneath this muscle is the bursa underneath the quadriceps, which in the adult communicates with the upper part of the knee-joint.

A somewhat arbitrary division may be made between the vastus internus and crureus by dissecting at the lower third of the thigh in a line with the inner border of the patella. With a few touches of the scalpel a longitudinal separation may be made clear, which extends upwards to the lower part of the anterior intertrochanteric line. The part of the muscle external to this line is the *crureus*, and the part internal the *vastus internus*.

The **ligamentum patellæ** may be looked upon as the common tendon of the quadriceps. It is a band of fibrous tissue about an inch (2·5 cm.) broad by one-quarter of an inch (6 mm.) thick, and two or three inches (5 to 7·5 cm.) in length, which is attached above to the apex and to the lower part of the posterior surface of the patella; and, after passing downwards and very slightly outwards, it is inserted into the anterior surface of the tubercle of the tibia. Attached to its sides are strong aponeuroses by which the lower fibres of the vastus externus and vastus internus and the ilio-tibial band are inserted into the tuberosities of the tibia, and which blend on their deep surface with the lower part of the capsule of the knee-joint.

Nerve-supply.—Numerous branches from the anterior crural are distributed to the upper half of the front of the crureus muscle and to the inner surface of the vastus internus at the junction of the middle and lower thirds of the thigh, the nerve to the vastus internus being a large and conspicuous branch which lies close to the outer side of the superficial femoral artery in the upper part of Hunter's canal.

Action.—The vastus externus, crureus, and vastus internus, together with the rectus femoris, extend powerfully the knee. Their intermediate insertion into the sesamoid bone formed by the patella serves to lift from the line of the tibia the ligamentum patellæ, which may be looked upon as the lower part of their common tendon. The enormous power of the whole of this combination of muscles is necessitated partly by the fact that the whole of the weight of the body has to be raised by it, and partly by the great mechanical disadvantage which results from the short arm of the lever upon which the tendon acts, and the obliquity of its insertion.

On account of the direction of the femur, which is downwards and inwards, the tendency of the quadriceps is to draw the patella outwards at the same time as upwards. This is in some degree counteracted by the position and direction of the vastus internus. The great mass of the fibres of this part of the quadriceps arises in the lower part of the thigh, and is directed so transversely outwards towards the inner border of the patella, that when it contracts it tends to draw the patella inwards as well as upwards, and so the resultant of the various divisions of the quadriceps when contracting simultaneously is to draw the patella more directly upwards. If it were not for this arrangement, the contraction of the quadriceps would have a strong tendency to produce outward dislocation of the knee-cap.

Relations of vastus externus, crureus, and vastus internus.—In front lie the fascia lata, tensor vaginæ femoris, rectus femoris, and sartorius. To the inner side lie the femoral vessels and anterior crural nerve. On the outer side are the gluteus minimus and maximus. Behind are the biceps on the outer side of the femur, and the adductor longus and magnus on the inner side.

Variations.—These are few in number. An accessory head to the rectus from the anterior superior spine of the ilium has been described, and occasionally the outer head is absent.

THE DEEP FASCIA OF THE LEG AND ANNULAR LIGAMENTS

The **deep fascia of the leg** is continuous above with the fascia lata of the thigh and receives important additions from the tendons of the quadriceps, biceps, sartorius, gracilis, and semi-tendinosus. It is also attached to the lower part of the outer and inner tuberosities of the tibia and to the head of the fibula. At the back of the knee it is strengthened by transverse fibres which serve to bind together the muscles which form the boundaries of the popliteal space; the external saphenous vein also perforates it about the centre of the space. It is very thick and strong at the upper and outer part of the front of the leg; but behind, where it covers the muscles of the calf, the fascia becomes much thinner. The internal surface of the tibia is not covered by this fascia, which blends with the periosteum covering its anterior and inner borders throughout their whole length. It is also attached to the borders of the fibula by two strong intermuscular septa which form the anterior and posterior walls of a compartment containing the long and short peronei. In the lower third of the leg it is attached to the borders of the subcutaneous surface of the fibula. In the neighbourhood of the ankle the deep fascia is thickened by the addition of numerous transverse fibres, and forms the annular ligaments.

The **anterior annular ligament** (fig. 298) consists of two parts, an *upper* and a *lower*. The *upper part* is a strong band of transverse fibres just above the ankle-joint, which extends from the anterior border of the tibia to the anterior border of the subcutaneous surface of the fibula. Behind it there is a separate synovial sheath for the tendon of the tibialis anticus. The *lower part* of the anterior annular ligament arises from the upper surface and outer border of the great process of the calcaneum in two bands, a superficial and a deep, which, passing transversely inwards, unite after a course of about an inch (2·5 cm.), and thus form a loop in which are contained the tendons of the extensor longus digitorum and the peroneus tertius, together with part of the origin of the extensor brevis digitorum.

From the inner extremity of this loop, two bands of fibres of varying distinctness proceed: one passes upwards and inwards to join the front border of the internal malleolus; the other, which is usually the weaker, more directly inwards over the scaphoid bone to join the inner border of the plantar fascia. Beneath this inner portion of the lower part of the anterior annular ligament the tendons of the extensor proprius hallucis and tibialis anticus are contained in separate synovial sheaths.

The **external annular ligament** passes from the posterior border of the external malleolus to the outer border of the tuberosity of the calcaneum and to the posterior part of the junction of the lower and outer surfaces of the calcaneum. It is continuous above with the deep fascia covering the calf muscles and the peronei; and also with the sheet of fascia which separates the two superficial from the two deeper layers of muscles at the back of the leg. Its deep surface is attached to the peroneal tubercle on the outer side of the calcaneum.

The **internal annular ligament** extends from the posterior border of the internal malleolus to the inner border of the tuberosity of the calcaneum. It is also continuous above with the deep fascia of the leg and with the sheet of fascia which intervenes between the soleus and the deeper layers of muscle at the back of the leg.

MUSCLES OF THE BACK OF THE LEG

The muscles in this region are arranged in two layers above, in four below. The first layer consists of the gastrocnemius and plantaris.

FIRST LAYER

1. GASTROCNEMIUS

The **gastrocnemius**—named from *γαστήρ* = the belly, and *κνήμη* = the calf, because it forms the enlargement of that part of the leg—is double-headed, each head consisting of a fusiform muscle, the lower part of which blends with its fellow so as to form a common tendon of insertion. These two heads constitute the femoral origin of the great triceps suræ muscle.

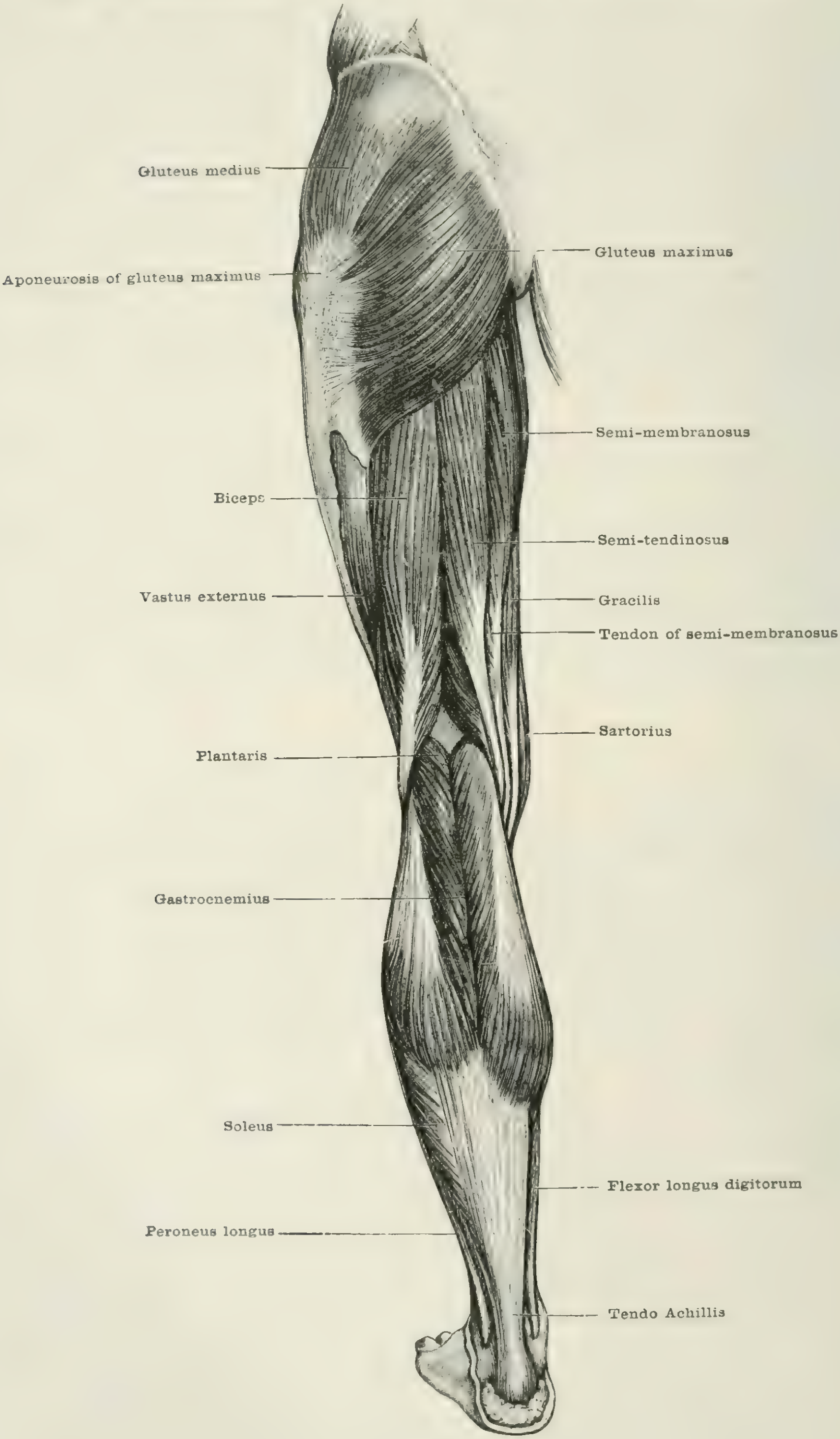
Origin.—Outer head: a well-marked impression upon the upper and posterior part of the outer surface of the external condyle and the adjacent part of the posterior surface of the femur just above the external condyle.

Inner head: an oval impression placed transversely across the posterior surface of the femur above the internal condyle, and reaching inwards to the back of the adductor tubercle.

Insertion.—By the tendo Achillis (so named from the legend that the heel, into which this tendon is inserted, was the only vulnerable part of the hero Achilles) into the middle area on the posterior surface of the calcaneum.

Structure.—The two heads arise by short strong tendons; that of the inner is the stronger and thicker. These tendons converge downwards, and are succeeded by large fleshy expansions which unite at the upper part of the middle third of the leg. Near this point the tendon of insertion begins as an intermuscular septum between the two bellies of the muscle. This becomes thicker and stronger, and expands into a broad aponeurosis which covers the anterior surface of the united muscle. Just below the middle of the leg the fleshy fibres terminate upon the back of this aponeurosis in two curves the convexity of which is downwards, that of the inner portion of the muscle descending about half an inch (1·2 cm.) lower than the outer. The strong aponeurosis becomes narrower and at the same time thicker, and after receiving the fibres of the soleus muscle is known by the name of the tendo Achillis.

FIG. 291.—SUPERFICIAL MUSCLES OF THE BACK OF THE THIGH AND LEG.


Gluteus medius
Aponeurosis of gluteus maximus
Gluteus maximus
Semi-membranosus
Biceps
Semi-tendinosus
Vastus externus
Gracilis
Tendon of semi-membranosus
Sartorius
Plantaris
Gastrocnemius
Soleus
Flexor longus digitorum
Peroneus longus
Tendo Achillis

Nerve-supply.—From the internal popliteal branch of the great sciatic nerve, which sends sural branches to the adjacent portions of the anterior surfaces of the two heads, in the upper third of the leg.

Action.—Its action will be described with that of the soleus, which forms a part of the same muscle.

Relations.—Behind, the deep fascia, the external saphenous vein and nerve, and the communicans peronei nerve. Between the two heads above is the plantaris muscle. In front lie the knee-joint, the tendon of the semi-membranosus, the popliteus, the plantaris tendon, the soleus, the popliteal vessels, and internal popliteal nerve. On the outer side, above, are the biceps tendon, and external popliteal nerve; on the inner side, above, are the tendons of the semi-tendinosus, gracilis, sartorius, and adductor magnus. A bursa lying beneath its inner head separates it from the tendon of the semi-membranosus, and communicates with the knee-joint.

Variations.—The most common variation is the addition of a third head from the posterior surface of the lower end of the femur. This may cross, or even run between, the popliteal vessels.

2. PLANTARIS

The **plantaris**—named from its occasional attachment to the fascia covering the sole of the foot (=*planta*)—is a fusiform, somewhat flattened muscle with a very long ribbon-shaped tendon.

Origin.—(1) The lower two inches (5 cm.) of the outer condylar ridge together with the posterior surface of the femur immediately below that ridge; and (2) the adjacent part of the posterior ligament of the knee-joint.

Insertion.—The inner side of the lower portion of the posterior surface of the calcaneum; sometimes, however, it blends with the inner border of the tendo Achillis, and sometimes it is continued into the inner division of the plantar fascia.

Structure.—Arising fleshy, the fibres of this small muscle have a somewhat penniform arrangement and converge upon the thin tendon, which appears first on the inner side of the muscle, and soon becoming free, runs downwards and slightly inwards across the calf between the gastrocnemius and the soleus. In the lower third of the leg it lies along the inner border of the tendo Achillis, with which it is sometimes blended.

Nerve-supply.—From the internal popliteal branch of the great sciatic nerve by a small filament which enters the deep aspect of the muscle near the upper part of its inner border.

Action.—This vestigial muscle is a feeble extensor of the ankle and a flexor of the knee-joint. By its attachment to the posterior ligament of the knee-joint it will tend to draw backwards that ligament during flexion of the knee, and so prevent its being caught between the articular surfaces.

Relations.—Behind lie the fascia of the popliteal space, the biceps, the gastrocnemius, and the external popliteal nerve; in front are the popliteal vessels and internal popliteal nerve, the popliteus muscle and the soleus.

Variations.—In addition to the above-mentioned variations in the point of insertion, this muscle may sometimes be double at its origin, and it is not unfrequently absent.

SECOND LAYER

The second layer is formed above by the popliteus, which is covered behind by the aponeurosis derived from the semi-membranosus; and below by the soleus, which is the lower head of the great triceps suræ muscle.

1. POPLITEUS

The **popliteus** (fig. 292)—named from its position on the floor of the ham (=*poples*)—is a triangular sheet.

Origin.—The bottom of the anterior portion of a horizontal groove on the lower part of the outer surface of the external condyle of the femur; also by a small slip from the posterior ligament of the knee-joint.

Insertion.—(1) The back of the tibia from below the attachment of the posterior ligament of the knee-joint to the oblique line; (2) the fascia derived from the tendon of the semi-membranosus, which covers the posterior surface of the muscle.

Structure.—Arising by a somewhat flattened cylindrical tendon which passes at first backwards and slightly downwards within the knee-joint, grooving the posterior border of the external semilunar cartilage; it then escapes from the capsule of the knee-joint, receiving a small slip from the posterior ligament, and immediately expands into a fan-shaped muscle which forms a thick sheet, covering the upper fourth of the back of the tibia, and is inserted by fleshy fibres into the pouch formed by the bone in front and the aponeurosis derived from the semi-membranosus behind. The tendon of origin is surrounded by synovial membrane, which is reflected upon it about half an inch (1·2 cm.) beyond the opening, through which it emerges from the posterior ligament of the knee-joint.

Nerve-supply.—From the sacral plexus by the internal popliteal division of the great sciatic nerve, which sends a special branch round the lower border of the muscle to distribute itself to the lower part of its deep or anterior surface.

Action.—To flex the knee, which it will do but feebly on account of the obliquity of its direction and its proximity to the axis of the joint. When the knee is flexed it will act as an internal rotator of the leg. In this position the tendon of origin lies wholly in the groove for its reception upon the outer surface of the external condyle. It is possible that the attachment of the tendon of origin to the posterior ligament of the knee may enable the muscle when it contracts to draw backwards the ligament, and so prevent the synovial membrane upon the anterior aspect of the ligament from being nipped between the articular surfaces.

Relations.—Behind, the aponeurosis of the semi-membranosus, the gastrocnemius, plantaris, and the popliteal vessels, the internal popliteal nerve, and the lymphatic glands. In front, the knee-joint. Superficial to the tendon of origin is the external lateral ligament of the knee.

Variations.—A second head of origin has been seen from a sesamoid bone in the outer tendon of the gastrocnemius.

2. SOLEUS

The **soleus**—named from *solea*, the Latin for a sole-fish, because of the resemblance of the muscle to this flat fish—is a thick, fusiform sheet which forms the lowest head of the triceps suræ muscle.

Origin.—(1) The oblique line of the tibia and the inner border of its posterior surface, from the lower end of the oblique line to a little below the middle of the leg; (2) the back of the head and the upper third of the outer border of the posterior or flexor surface of the fibula and the adjacent external intermuscular septum; (3) a tendinous arch which stretches across the interval between the upper part of the back of the tibia and fibula.

Insertion.—By a strong aponeurosis which blends with the anterior surface of the tendon of the gastrocnemius, and forms the tendo Achillis.

Structure.—The muscle arises partly by fleshy fibres and partly by a strong aponeurosis, which lies in front of the fleshy fibres, and is especially noticeable in the neighbourhood of its tibial attachment. From the tibia and fibula the fibres pass in a bipenniform arrangement downwards and towards the middle line, and after a very short course, not exceeding two inches (5 cm.) in length, they blend with the tendon of insertion which begins near the upper part of the origin of the muscle, and in cross-sections of the muscle resembles in shape the letter **T**; one part of it forming a broad aponeurosis upon the posterior surface of the muscle, the other part a strong tendinous septum which passes forwards from the middle of the broad aponeurosis above mentioned, so as to separate the fleshy fibres into two portions. About the junction of the middle and lower thirds of the leg, the tendon of insertion joins by its posterior aspect with that of the gastrocnemius muscle, but upon its anterior aspect and sides it receives fleshy fibres nearly as far down as the back of the ankle-joint. The **tendo Achillis** is a strong rounded band of tendon about three-quarters of an inch (2 cm.) from side to side, and about half as much from before backwards; it is narrowest at the level of the ankle-joint, and expands slightly before it is inserted into the lower part of the posterior surface of the calcaneum. A bursa intervenes between the tendon and the smooth upper part of the posterior surface of this bone.

Nerve-supply.—From the internal popliteal division of the great sciatic nerve by sural branches which enter the upper half of the muscle upon the posterior surface; and lower down by a branch from the posterior tibial nerve, which enters the anterior surface of the muscle.

Action.—The chief action of the combined gastrocnemius and soleus is to extend the ankle-joint. It is an extremely powerful muscle, as it acts with considerable mechanical disadvantage. The lever by means of which it acts may be best described as one of the first order (see page 285); the lever being that part of the foot which lies between the heel and the heads of the metatarsal bones, the ankle being the fulcrum; a pressure equal to the weight of the body being exerted by the ground at the anterior extremity of the lever; and the arm, at the end of which the muscle acts, being the comparatively short distance between the back of the heel and the centre of the ankle-joint. When the ankle-joint has been completely extended, this muscle will tend to adduct slightly the foot, and to invert the sole, this movement being carried out in the joint between the astragalus and calcaneum. Besides extending the ankle, the gastrocnemius will assist in flexing the knee-joint. The chief object, however, which appears to be gained by the femoral attachment of this muscle is the addition to the rapidity of extension of the foot. Like some of the other long muscles which pass over two joints, the gastrocnemius, if it were an inextensible ligament, would cause extension of the ankle as soon as the knee was straightened by means of the great quadriceps muscle. Seeing, however, that during the contraction of the quadriceps the gastrocnemius is at the same time acting, it follows that the rapidity and amount of the extension of the ankle-joint is almost doubled. By these means we obtain that rapid and powerful contraction which gives the spring to the body in leaping and running. We may see also how enormously strong the tendo Achillis must be, as it has not only to bear the contraction of the gastrocnemius and soleus, but the additional strain thrown upon it by the simultaneous action of the quadriceps extensor of the knee. The soleus will assist in the extension of the ankle, and will even be able to perform this movement somewhat feebly by itself, when in extreme flexion of the knee-joint the gastrocnemius is so relaxed as to be almost powerless. It is much stronger than the gastrocnemius, as may be inferred from the enormous number of short fibres of which it is formed. At the same time, however, as it only passes over the ankle and calcaneo-astragaloid joints, the range of its movements is very short.

Relations.—The soleus is in relation behind with the gastrocnemius and plantaris; in front, with the flexor longus digitorum, flexor longus hallucis, and tibialis posticus, and with the posterior tibial vessels and nerve.

Variations.—A second soleus is sometimes found beneath the normal muscle, and more or less separate from it. It is usually inserted into the calcaneum or internal annular ligament.

Third Layer

The **third layer** is separated from the superficial layers by an aponeurosis called the **deep tibial fascia.** This is attached to the inner border of the tibia internally, and externally to the outer border of the flexor surface of the fibula, and the posterior of the two external intermuscular septa. It is thin above, but below it is strengthened by transverse fibres, and becomes much thicker. At the ankle it blends with the deep fascia of the leg and the external and internal annular ligaments. The third layer consists of two muscles—the flexor longus digitorum and the flexor longus hallucis.

1. FLEXOR LONGUS DIGITORUM PEDIS

The **flexor longus digitorum**—named from its being the longer of the two flexors of the toes—is a fusiform sheet.

Origin.—(1) The inner part of the posterior surface of the tibia, beginning with the lower half of the oblique line, and ending about three inches (7·5 cm.) above the inner ankle; (2) the front of the deep fascia which covers the sheet; (3) a thin intermuscular septum which intervenes between this muscle and the tibialis posticus.

Insertion.—The under surface of the base of the ungual phalanx of each of the four outer toes.

Structure.—Arising fleshy from the tibia and adjacent fasciæ, the fibres pass in a penniform manner into the front and outer side of a tendon which, beginning about the middle of the leg, gradually becomes thicker and stronger, and receives its last fleshy fibres about two inches (5 cm.) above the ankle-joint. It then passes beneath the internal annular ligament in a compartment posterior and external to that for the tibialis posticus. Thence it runs downwards, forwards, and outwards beneath the first layer of the sole muscles, and, after having received fleshy fibres from the accessorius pedis and a small tendinous slip from the tendon of the flexor longus hallucis, divides, about half-way between the tuberosity of the calcaneum and the heads of the metatarsal bones, into four tendons. These enter the thecæ of the four outer toes, and each tendon passes through the splitting of the tendon of the flexor brevis digitorum to its insertion upon the under surface of the base of the third phalanx. The lumbricales arise from its tendons in the sole of the foot.

Nerve-supply.—From the posterior tibial nerve by branches which enter the superficial aspect of the muscle near its outer border about the middle of the leg.

Action.—To flex the last phalanges of the four outer toes; it will then help to flex the second and first phalanges and the medio-tarsal joint of the foot. It will also help slightly in the extension of the ankle-joint. In flexing the medio-tarsal joint, it will tend to preserve the arch of the instep.

Relations.—Superficially, in the leg the soleus, posterior tibial vessels and nerve; in the foot, the abductor hallucis and flexor brevis digitorum. Deeply, the tibialis posticus in the leg, and in the foot the tendon of the flexor longus hallucis, the accessorius, and the muscles which form the inner part of the third layer of the sole of the foot.

Variations.—An accessory head sometimes arises in the leg from the fibula, the tibia, or the deep fascia of the leg; it may join the rest of the muscle in the leg, or in the sole. Some of the tendons to the toes may be wanting; more often they are increased in number and supply the deficiencies of the flexor brevis digitorum, and especially by sending slips to the little toe.

2. FLEXOR LONGUS HALLUCIS

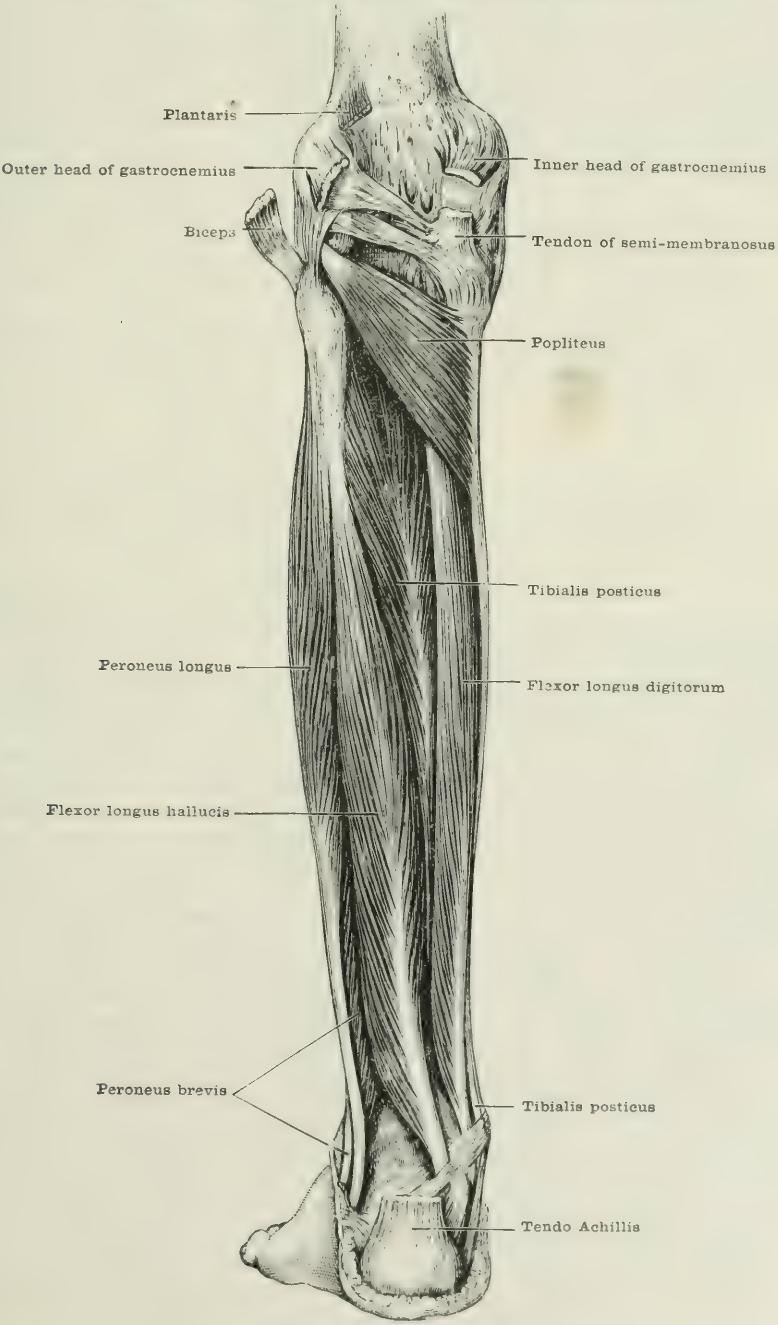
The **flexor longus hallucis**—named from its action upon the great toe (*hallux*) and its length—is a strong fusiform sheet.

Origin.—The lower two-thirds of the posterior (or flexor) surface of the fibula external to the oblique line; (2) the intermuscular septa between it and the tibialis posticus in front, and the peronei outside; (3) the deep fascia covering its posterior surface; and sometimes (4) the lowest portion of the interosseous membrane.

Insertion.—(1) The under surface of the base of the last phalanx of the great toe; (2) by a small slip into that part of the flexor longus digitorum tendon which is distributed to the second and third toes.

Structure.—The muscle arises by fleshy fibres which pass with a bipenniform arrangement into the tendon. This tendon appears first just below the middle of the leg at the back of the muscle near its inner border. The fleshy fibres are inserted into it as far as the ankle-joint, and just above this point the tendon passes through the groove at the outer part of the back of the lower end of the tibia. The tendon then grooves the back of the astragalus, and afterwards the under surface of the sustentaculum tali, where it lies external to the tendon of the flexor longus digitorum. From this point it passes forwards in the second layer of the muscles of the sole, lying above and crossing the tendon of the flexor longus digitorum, to

FIG. 292.—THE DEEP MUSCLES OF THE BACK OF THE LEG.


Plantaris
Outer head of gastrocnemius
Inner head of gastrocnemius
Biceps
Tendon of semi-membranosus
Popliteus
Tibialis posticus
Peroneus longus
Flexor longus digitorum
Flexor longus hallucis
Peroneus brevis
Tibialis posticus
Tendo Achillis

which it gives a small slip. It then crosses beneath the inner head of the flexor brevis hallucis, lies in the groove between the sesamoid bones of that muscle, and is finally inserted into the base of the last phalanx.

Nerve-supply.—From the posterior tibial nerve by branches which enter the muscle in the upper part of its posterior surface near its inner border.

Action.—This muscle, which is much more powerful than the flexor longus digitorum, is a strong flexor of the last phalanx of the great toe, and is of great importance in walking, as it presses the great toe firmly against the ground. The ungual phalanx of the great toe is the last part of the foot to leave the ground when the step is completed; and until this is the case the flexor longus hallucis is strongly contracted. It will also help to flex the first phalanx of the great toe upon its metatarsal bone and it will act upon the joints which intervene between the first metatarsal bone and the astragalus so as to support the arch of the instep; and, finally, it will assist in the extension of the ankle-joint. By the slip which it gives to the flexor longus digitorum it will help that muscle in flexing the adjacent toes.

Relations.—Superficially, in the leg, it is covered by the soleus, and in the foot by the abductor hallucis, the flexor longus digitorum, the external plantar vessels and nerve; on its outer side are the peronei; on its deep aspect in the leg lie the tibialis posticus and the peroneal vessels; and, after passing over the back of the ankle and other joints, it lies upon the inner head of the flexor brevis hallucis.

Variations.—An accessory portion of the muscle may be inserted into the sustentaculum tali or the inner surface of the calcaneum. The slip to the flexor longus digitorum tendon may vary in the number of toes to which it is distributed.

FOURTH LAYER

The fourth layer consists of one muscle—the tibialis posticus.

TIBIALIS POSTICUS

The **tibialis posticus**—named from its position in the back part of the leg and its origin from the tibia—is a thick fusiform sheet.

Origin.—(1) The whole of the back of the interosseous ligament with the exception of the lowest portion; (2) the posterior surface of the tibia close to the interosseous line, from the upper end of the oblique line to the junction of the middle and lower thirds of the shaft; (3) the internal (or inner part of the flexor) surface of the fibula at the back of the interosseous ridge to within a short distance of the ankle; (4) the intermuscular septa which intervene between it and the muscles of the third layer, viz. the flexor longus hallucis and the flexor longus digitorum; and (5) a small portion of the deep tibial fascia which separates the second from the third layer.

Insertion.—(1) The tuberosity of the scaphoid bone; (2) by several smaller offsets into the front of the lower surface of the sustentaculum tali and the under surface of all the other tarsal bones with the exception of the astragalus; and (3) the under surface of the bases of the second, third, and fourth metatarsal bones.

Structure.—A strong bipenniform muscle, the central tendon of which, lying upon the middle of the back of the muscle, begins about the middle of the leg, and passes downwards and inwards upon the back of the muscle, receiving its last fleshy fibres about an inch (2·5 cm.) above the ankle. Having passed inwards beneath the tendon of the flexor longus digitorum, it enters the innermost groove on the back of the internal malleolus, and is contained in a synovial sheath which accompanies it to its insertion upon the scaphoid bone. From this insertion strong fibrous bands radiate backwards, outwards, and forwards to the tarsal and metatarsal bones, being intimately blended with the ligaments by which these bones are held together. This muscle, which is very strong, is contained, so to speak, in a long four-sided case formed in the front by the interosseous membrane; at the sides, by the opposing surfaces of the tibia and fibula; and behind, at a distance of nearly half an inch (1·2 cm.) from the interosseous membrane, by the intermuscular septa which separate the muscle from the flexor longus hallucis and the flexor longus digitorum.

Just above its insertion into the tuberosity of the scaphoid bone, the tendon often contains a sesamoid bone.

Nerve-supply.—From the posterior tibial, which sends branches forwards to the back of the muscle in the upper third of the leg.

Action.—(1) To adduct the front of the foot; (2) to invert the sole; (3) to extend the ankle—the last of these movements is somewhat limited; (4) to support the longitudinal arch of the foot—first, by drawing backwards the lower part of the scaphoid, and so preventing the descent of the head of the astragalus between the scaphoid and calcaneum, and secondly by its traction upon the other tarsal bones into which the secondary offsets of its tendon are inserted.

Relations.—Superficially, the soleus and third layer of muscles of the leg, the posterior tibial and peroneal vessels and the posterior tibial nerve above; in the sole the tendon of the flexor longus digitorum and the abductor hallucis; deeply, the ankle-joint and inferior calcaneo-scaphoid ligament. The anterior tibial vessels pass through a notch at the upper extremity of the muscle, between its tibial and fibular origins.

THE FASCIA AND MUSCLES OF THE SOLE OF THE FOOT

The **plantar fascia** is, like the corresponding fascia in the palm, very strong, and is divided into three parts. The **central part,** which is the strongest, arises from the under surface of the calcaneum at the back of the tubercles. It is triangular, the apex being attached behind, and the expanded base dividing near the heads of the metatarsal bones into five divisions, one for each of the toes. Each division forms an arch over the tendons entering the toe, and is continuous with the ligamentum vaginale of the theca. The sides of the arch pass upwards to be attached to the deep transverse ligament which connects the heads of the metatarsal bones, and to the lateral ligaments of the metatarso-phalangeal joints. The under surface of the fascia is attached to the deep surface of the skin by small fibrous bands which form the walls of compartments containing pellets of fat. These fibrous connections give firmness to the skin of the sole and prevent it from being moved about upon the subjacent fascia. The borders of the central portion of the plantar fascia are continued upwards into the sole by the *internal* and *external intermuscular septa*, which are attached above to the fibrous structures on the under surfaces of the tarsal bones. The **inner portion,** which is the thinnest division of the plantar fascia, is attached behind to the inner border of the great tubercle of the calcaneum and to the lower border of the internal annular ligament. It is inserted in front upon the inner side of the base of the first phalanx of the great toe, and above it becomes continuous with the deep fascia covering the instep. The **external portion** is very thick, and arises from the outer border of the lesser tubercle of the calcaneum and the lower border of the external annular ligament. It terminates in front in the base of the first phalanx of the little toe, and at its inner border it blends with the central portion of the plantar fascia, where it is joined by the external intermuscular septum; upon its outer border it is closely connected with the base of the fifth metatarsal bone, and it is continuous with the deep fascia covering the instep.

In the web between the toes some thin transverse fibres are found, the **superficial transverse ligament** of the toes. They bridge over part of the interval between the five slips into which the front part of the central division of the plantar fascia breaks up.

The muscles and tendons in the sole of the foot are divided into four layers. The first layer consists of three muscles, which correspond in their position to the three compartments formed by the plantar fascia and the two intermuscular septa, viz. the abductor hallucis, the flexor brevis digitorum, the abductor minimi digiti.

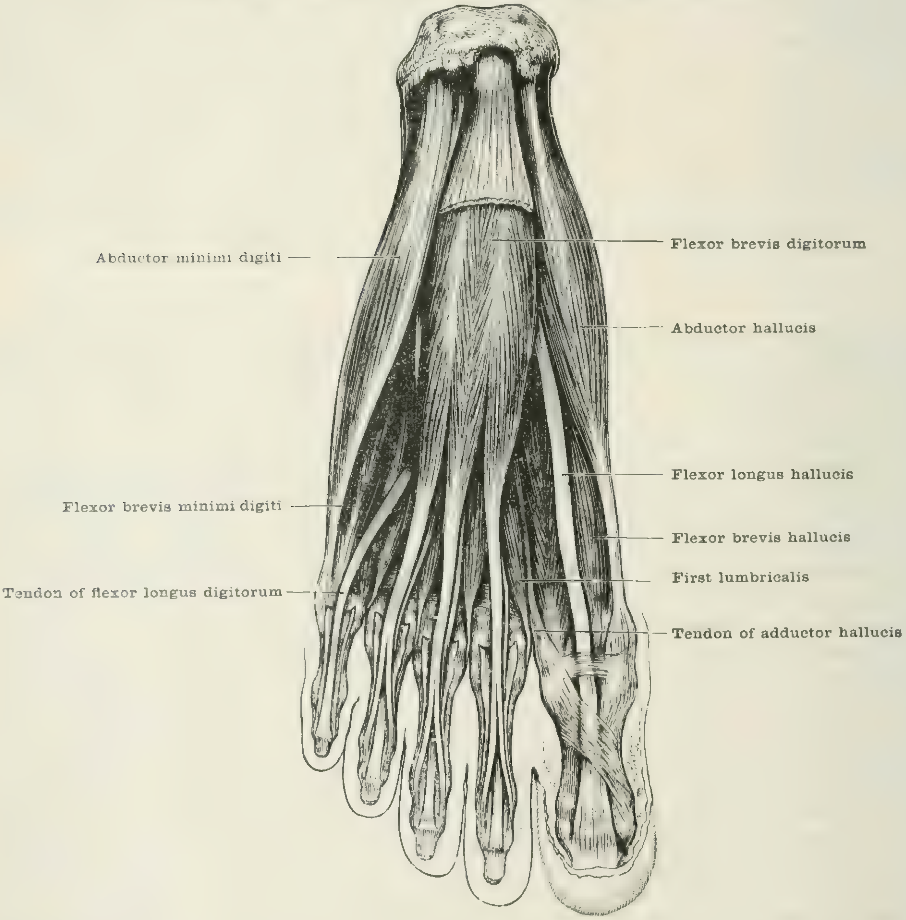
FIRST LAYER

1. ABDUCTOR HALLUCIS

The **abductor hallucis**—named from its action upon the great toe—is a thick triangular sheet, with a broad origin behind, which is divided into two heads.

Origin.—Outer head: (1) The front and inner surfaces of the inner or greater tubercle on the under surface of the calcaneum; (2) the deep surface of the inner portion of the plantar fascia; (3) the intermuscular septum which separates it from the flexor brevis digitorum. **Inner head**: (1) The deep aspect of the lower border of the internal annular ligament; (2) the under surface of the attachment of the tendon of the tibialis posticus to the tuberosity of the scaphoid bone and the adjacent prolongations of this tendon.

FIG. 293.—FIRST LAYER OF THE MUSCLES OF THE SOLE.


Abductor minimi digiti
Flexor brevis digitorum
Abductor hallucis
Flexor longus hallucis
Flexor brevis minimi digiti
Flexor brevis hallucis
First lumbricalis
Tendon of flexor longus digitorum
Tendon of adductor hallucis

Insertion.—The inner part of the lower surface of the base of the first phalanx of the great toe and the inner side of the internal sesamoid bone. Occasionally, also, the inner border of the expansion of the extensor proprius hallucis on the back of the first phalanx.

Structure.—The outer head arises in close connection with the flexor brevis digitorum by short tendinous fibres, soon succeeded by a divergent fleshy bundle which is joined about two inches (5 cm.) from its origin by the fleshy sheet formed by the inner head. The tendon to which these fleshy fibres converge appears first upon the inner and lower aspect of the muscle, and receives fleshy fibres nearly to its insertion, which is closely blended with that of the inner portion of the flexor brevis hallucis. The deep surface of the muscle arises from a fibrous arch attached on the one side to the septum between it and the flexor brevis digitorum; on the other side to the tibialis posticus tendon and the fibrous tissue covering the under surface of the tarsal bones along the inner border of the foot. Through this arch pass the plantar vessels and nerves.

Nerve-supply.—The internal plantar division of the posterior tibial nerve, by filaments which enter the deep surface of the middle of the muscle.

Action.—(1) To flex the first phalanx upon the metatarsal bone; (2) to abduct from the middle line of the foot the first phalanx of the great toe.

Relations.—Superficially, the internal division of the plantar fascia; upon its outer border, the flexor brevis digitorum; deeply, the tendons of the tibialis anticus, tibialis posticus, flexor longus digitorum, flexor longus hallucis, the plantar vessels and nerves.

Variations.—A third head is occasionally derived from the deep surface of the skin upon the inner border of the foot, or from the long plantar ligament. The muscle may give a slip to the second toe.

2. FLEXOR BREVIS DIGITORUM PEDIS

The **flexor brevis digitorum pedis,** or **flexor perforatus**—named from its being the shorter of the flexors of the four outer toes—is a triangular sheet, divided in front into four processes corresponding to the tendons of the toes.

Origin.—(1) The outer part of the front of the lower surface of the great tubercle of the calcaneum; (2) the deep surface of the back part of the central portion of the plantar fascia; (3) the back part of the intermuscular septa on either side.

Insertion.—The sides of the middle phalanx of each of the four outer toes upon its plantar aspect.

Structure.—Arising tendinous by a pointed process from the under surface of the great tubercle, the fleshy fibres extend in a fan-shaped sheet, which, about halfway between the origin and the heads of the metatarsal bones, divides into four fleshy processes which soon become tendinous. The tendons are arranged in a similar manner to those of the flexor sublimis digitorum in the hand. After splitting beneath the first phalanx of the toe, the two halves of each tendon pass round the sides of the flexor longus digitorum tendon, and about the level of the base of the second phalanx they unite by their adjacent margins, and again diverge to be attached to the sides of the plantar surface of the second phalanx.

Nerve-supply.—From the internal plantar division of the posterior tibial, by branches which enter the back of the deep aspect of the muscle near its inner border.

Action.—This muscle, which is comparatively feeble, will flex the second phalanges of the toes, and in combination with the flexor longus digitorum it will assist in walking, by pressing the under surface of the phalanges of the toes against the ground. After it has flexed the second phalanges, it will act in a similar manner upon the metatarso-phalangeal and medio-tarsal joints.

Relations.—Superficially, the plantar fascia; on either side, the other muscles of the first layer of the sole; deeply, the tendons of the flexor longus digitorum and the lumbricales, the accessorius muscle, and the external plantar vessels and nerve.

Variations.—The part of the muscle which belongs to the little toe is often absent (see fig. 294), and its place may be supplied by a small perforated slip from the tendon of the flexor longus digitorum.

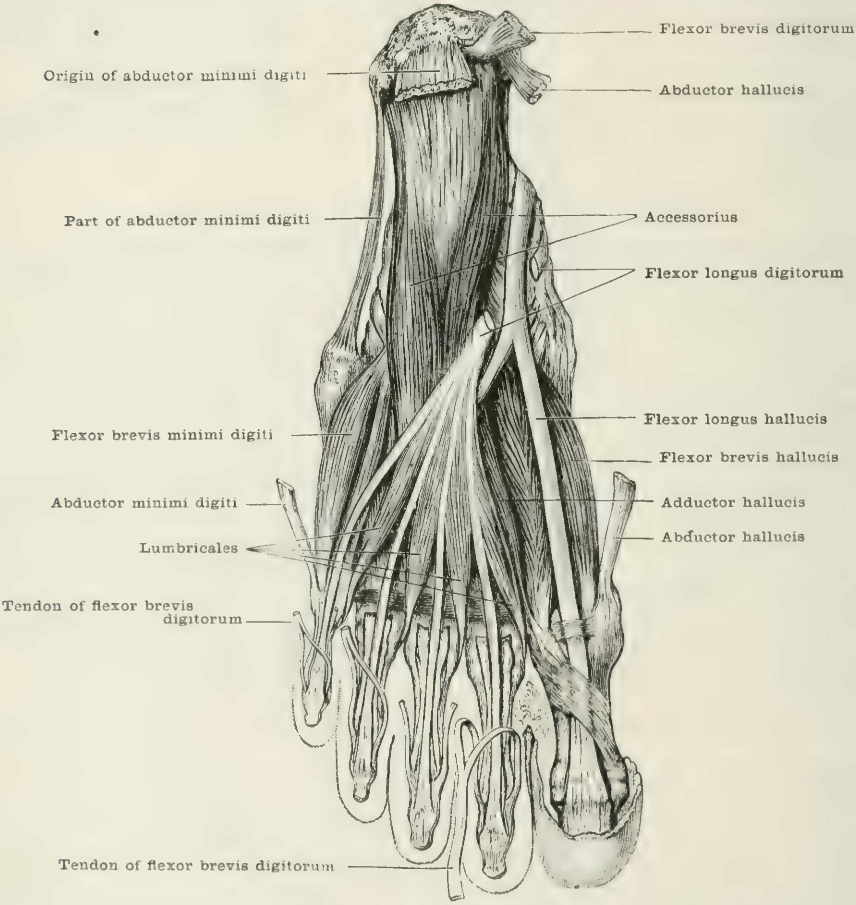
3. ABDUCTOR MINIMI DIGITI PEDIS

The **abductor minimi digiti** (**pedis**)—named from its action upon the fifth and smallest toe—is a thick triangular sheet, partly muscular and partly aponeurotic.

Origin.—(1) The outer side and the under surface of the front of the lesser tubercle of the calcaneum and the adjacent portion of the under surface of that bone in front of the great tubercle; (2) the upper surface of the back part of the outer division of the plantar fascia; (3) the outer surface of the back part of the external intermuscular septum; (4) the long plantar ligament and other ligamentous structures lying upon the outer border of the sole, and more especially an aponeurotic band which runs from the outer side of the lesser tubercle of the calcaneum to the outer side of the base of the fifth metatarsal bone, and of the base of the first phalanx of the fifth toe.

Insertion.—(1) The outer part of the under surface of the base of the first phalanx of the little toe; (2) usually also the outer part of the under surface of the base of the fifth metatarsal bone; (3) the outer edge of the fourth tendon of the extensor longus digitorum upon the back of the first phalanx of the little toe.

FIG. 294.—SECOND LAYER OF THE MUSCLES OF THE SOLE.


Flexor brevis digitorum
Origin of abductor minimi digiti
Abductor hallucis
Part of abductor minimi digiti
Accessorius
Flexor longus digitorum
Flexor longus hallucis
Flexor brevis minimi digiti
Flexor brevis hallucis
Abductor minimi digiti
Adductor hallucis
Abductor hallucis
Lumbricales
Tendon of flexor brevis digitorum
Tendon of flexor brevis digitorum

Structure.—The muscle, which is at first encased in the aponeuroses, from which as well as from the bone it takes origin, converges from both sides upon a tendon which is first visible on its under surface at the front of the calcaneum. A small portion of its outer part is now inserted into the tubercle of the fifth metatarsal bone, internal to the strong aponeurotic band which is also here attached. From this point the tendon of insertion is free on its inner side, but receives fleshy fibres still from the continuation of the aponeurotic band just mentioned, until it is inserted into the base of the first phalanx.

Nerve-supply.—From the external plantar division of the posterior tibial nerve, by filaments which enter the back part of the deep surface of the muscle near its inner border.

Action.—(1) To abduct the first phalanx of the little toe from the middle line; (2) to flex the metatarso-phalangeal joint of the little toe.

The usual action of the muscle will be a combination of these two movements.

Relations.—Superficially, the plantar fascia, the flexor brevis digitorum, and even a small portion of the abductor hallucis. Deeply, the accessorius, flexor brevis minimi digiti, long plantar ligament, and peroneus longus tendon.

Variations.—The muscular slip attached to the base of the fifth metatarsal bone is often so distinct as to form a separate muscle, the abductor ossis metatarsi quinti.

SECOND LAYER

The second layer consists of the flexor accessorius muscle, the four lumbricales, and the tendons of the flexor longus hallucis and the flexor longus digitorum.

1. FLEXOR ACCESSORIUS DIGITORUM PEDIS

The **flexor accessorius digitorum pedis**—named from its accessory or supplementary action in assisting the flexion of the toes by the flexor longus digitorum—is a double-headed quadrilateral sheet.

Origin.—Inner head: The whole of the concave inner surface of the calcaneum below the groove for the flexor longus hallucis.

Outer head: (1) The junction of the lower and outer surfaces of the calcaneum in front of the lesser tubercle; (2) the under surface of the back part of the long plantar ligament.

Insertion.—The upper surface and outer border of the flexor longus digitorum tendon about midway between the tubercles of the calcaneum and the heads of the metatarsal bones.

Structure.—Its inner head consists of fleshy fibres which converge from their origin in a somewhat fan-shaped sheet, and are joined shortly before their insertion into the tendon by the outer head, which consists of a pointed tendinous origin, from which the fleshy fibres form a somewhat smaller fan-shaped sheet which blends with that from the inner head, to be inserted by fleshy fibres upon the upper surface and outer border of the flexor longus digitorum, at its point of division into the tendons for the four outer toes.

Nerve-supply.—From the external plantar division of the posterior tibial nerve, by branches which enter the under surface of the muscle near its origin.

Action.—To help in the flexion of the last phalanges of the four outer toes, and at the same time to draw the toes somewhat outwards. On account of the oblique direction of the tendons of the flexor longus digitorum in the foot, they would tend in flexing the toes to draw them at the same time inwards. This tendency will be somewhat neutralised by the simultaneous contraction of the accessorius. The accessorius will also be able to flex the toes when, on account of the extension of the ankle-joint, the muscular fibres of the flexor longus digitorum are so relaxed as to be weakened in their action.

Relations.—Superficially, the flexor brevis digitorum, the abductor minimi digiti, the tendons of the flexor longus digitorum and flexor longus hallucis, with the external plantar vessels and nerve; deeply, the flexor brevis hallucis and long plantar ligament.

Variations.—An additional head may arise above the ankle from the flexor longus digitorum, flexor longus hallucis, or soleus. Sometimes the outer head is wanting, and occasionally the whole muscle is absent. The distribution of its fibres to the tendons of the long flexor is very variable. It may send fibres to the tendon of the flexor longus hallucis.

2. THE FOUR LUMBRICALES

The **four lumbricales**—named from their shape (*lumbricus* = an earthworm)—are, like those in the palm, four small fusiform muscles.

Origin.—The first, from the inner border of the innermost tendon of the flexor longus digitorum, from the point of division of the main tendon for about an inch (2·5 cm.) forwards; the other three, from the adjacent surfaces of the first and second, the second and third, and the third and fourth tendons of the flexor longus digitorum on their plantar aspect.

Insertion.—The inner border of the expansion of the extensor longus digitorum tendon upon the back of the first phalanx of each of the four outer toes.

Structure.—The origin of the muscle is entirely fleshy. It ends in a small rounded tendon a short distance above the web of the toes. This tendon runs forwards and upwards upon the inner side of its toe, above the superficial transverse ligament of the toes and beneath the deep transverse ligament of the metatarsus, to the side of the expansion of the extensor tendon.

Nerve-supply.—The innermost is supplied by the internal plantar division of the posterior tibial nerve, by filaments which enter the back part of the lower surface of the muscle near its inner border; the three outer, by the external plantar nerve, by filaments which enter the deep part of each muscle near its outer border.

Action.—(1) To flex the first phalanx of the toe; (2) to straighten the second and third phalanges. (3) The first will abduct the second toe from the axis passing through it, which is looked upon as the middle line of the foot. The three others will adduct. The lumbricales will be able to act upon the first phalanges, even when the second and third have been flexed by means of their special flexors. The chief advantage derived from the simultaneous extension of the two terminal phalanges and the flexion of the first phalanx is the application of the whole length of the toe to the ground in walking; otherwise there would be a strong tendency to the flexion of the phalanges of the toes, which would prevent the proper application of the soft plantar aspect of the ungual phalanx to the ground.

Relations.—Superficially, the flexor brevis digitorum. Deeply, the flexor longus digitorum tendons, the transversalis pedis, and the interossei.

Third Layer

The third layer consists of four muscles—the flexor brevis hallucis, the adductor hallucis, the transversus pedis, and the flexor brevis minimi digiti.

1. FLEXOR BREVIS HALLUCIS

The **flexor brevis hallucis**, or **flexor brevis pollicis pedis**—named from its action, and its size in comparison with the other flexor of the great toe—is a thick triangular sheet with a forked insertion.

Origin.—(1) The plantar ligaments and the continuations of the tibialis posticus tendon in the middle of the sole; (2) the inner part of the under surface of the cuboid bone.

Insertion.—The inner and outer borders of the plantar aspect of the base of the first phalanx of the great toe.

Structure.—Arising fibrous by a pointed process in the middle of the sole, the fibres diverge as they pass forwards and slightly inwards, and form two fleshy bundles of equal size, which are succeeded by short tendons. In each tendon is contained a sesamoid bone of ovoid shape about three-eighths of an inch (1 cm.) in the long antero-posterior diameter, and a quarter of an inch (7 mm.) from side to side, with a cartilaginous articular facet upon the upper surface which plays upon the lower surface of the condyle of the first metatarsal bone. At their insertion into the inner and outer part of the lower border of the base of the first phalanx, they are blended with the tendons of the abductor and the adductor hallucis.

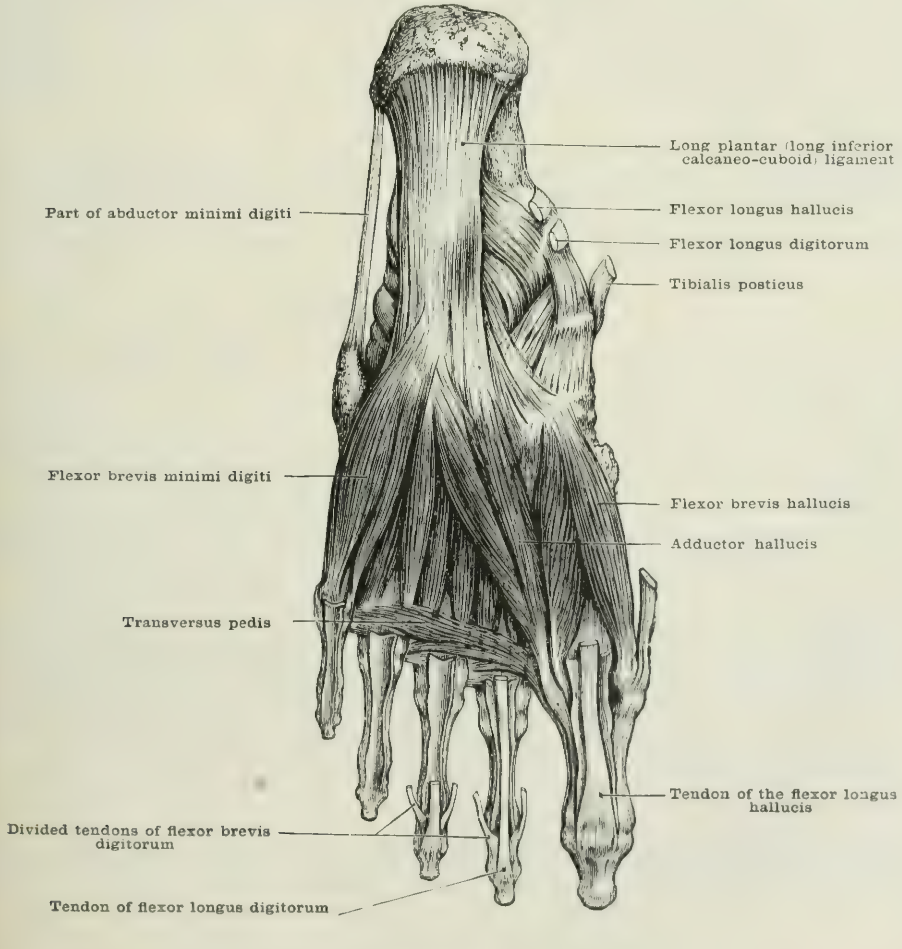
Nerve-supply.—From the internal plantar division of the posterior tibial nerve, by filaments which enter the under surface of the muscle near the middle of its inner border.

Action.—To flex and slightly adduct the first phalanx of the great toe. The sesamoid bones give a slight obliquity to its insertion, and so enable it to act with more power; at the same time they form a groove in which the strong tendon of the flexor longus hallucis plays. They also form a somewhat elastic support when the weight is placed upon the ball of the foot.

Relations.—Superficially, the abductor hallucis, the tendon of the flexor longus hallucis, and the inner tendons of the flexor longus digitorum with the lumbricales; deeply, the interossei and the termination of the external plantar vessels and nerve.

Variations.—A small slip is occasionally given to the first phalanx of the second toe.

FIG. 295.—THIRD LAYER OF THE MUSCLES OF THE SOLE.


Long plantar (long inferior calcaneo-cuboid) ligament
Part of abductor minimi digiti
Flexor longus hallucis
Flexor longus digitorum
Tibialis posticus
Flexor brevis minimi digiti
Flexor brevis hallucis
Adductor hallucis
Transversus pedis
Tendon of the flexor longus hallucis
Divided tendons of flexor brevis digitorum
Tendon of flexor longus digitorum

2. ADDUCTOR HALLUCIS

The **adductor hallucis**—named from its action upon the great toe—is a triangular sheet, the apex of which is directed forwards and inwards.

Origin.—(1) The continuation forwards of the long plantar ligament which forms the sheath of the peroneus longus tendon; (2) the under surface of the bases of the second, third, and fourth metatarsal bones.

Insertion.—The outer part of the under surface of the base of the first phalanx of the great toe.

Structure.—Arising by short tendinous fibres, the muscle converges in bipenniform fashion upon a short tendon, which blends with that of the flexor brevis hallucis and the outer sesamoid bone internally, and the transversus pedis externally.

Nerve-supply.—From the external plantar division of the posterior tibial nerve by filaments which enter the upper surface of the muscle upon its outer border near its origin.

Action.—(1) To adduct the first phalanx of the great toe towards the middle line of the foot; (2) to flex the first phalanx. Usually it will act during walking in combination with the flexor brevis hallucis and abductor hallucis, and the three muscles contracting together will produce direct flexion of the first phalanx, so that when the weight of the body rests upon the front part of the foot the second phalanx is pressed firmly against the ground by the action of the flexor longus hallucis, while the first phalanx is acted upon in the same manner by the combination of these three short muscles. As Duchenne has pointed out, the abductor and adductor will have an important function in adjusting the pressure when the step has to be made upon uneven ground. Thus, in walking upon a slope the adductor hallucis of the one foot will direct the pressure downwards and slightly outwards, while the abductor of the other foot will direct the pressure downwards and slightly inwards.

Relations.—Superficially, the flexor longus digitorum tendons and their lumbricales; deeply, the interossei with the external plantar vessels and nerve; at the sides, the flexor brevis hallucis and transversus pedis.

Variations.—The adductor hallucis sometimes sends a slip to the first phalanx of the second toe.

3. TRANSVERSUS PEDIS

The **transversus pedis**—named from the direction of its fibres—is a small muscle consisting of three or four fusiform bundles lying side by side, and uniting in a single tendon.

Origin.—(1) The plantar ligaments of the three outer metatarso-phalangeal joints; (2) the under surface of the adjacent deep transverse metatarsal ligaments.

Insertion.—The outer side of the base of the first phalanx of the great toe.

Structure.—The fleshy fibres form a series of small bundles which converge slightly as they pass inwards and somewhat forwards, and after uniting terminate in a short tendinous insertion which is closely blended with the outer surface of the tendon of the adductor hallucis.

Nerve-supply.—From the external plantar division of the posterior tibial nerve by filaments which pass to the upper part of the posterior edge of the muscle.

Action.—(1) To adduct the first phalanx of the great toe; (2) to draw together the heads of the metatarsal bones after they have been separated by the pressure of the weight of the body during the tread.

Relations.—Superficially, the flexor longus digitorum tendons and lumbricales; deeply, the interossei.

Variations.—Some or all of the bundles may be absent; most frequently the outermost one. Occasionally fibres join the muscle from the fascia covering the interossei below the lower border of the adductor hallucis, so that the two muscles are more or less blended.

4. FLEXOR BREVIS MINIMI DIGITI PEDIS

The **flexor brevis minimi digiti pedis**—named from its action upon the little toe—is small, flattened, and fusiform.

Origin.—(1) The under surface of the base of the fifth metatarsal bone; (2) the adjacent part of the sheath of the peroneus longus tendon.

Insertion.—(1) The outer part of the under surface of the base of the first phalanx of the little toe; (2) the outer part of the front of the under surface of the fifth metatarsal bone.

Structure.—Arising tendinous, the fleshy fibres run forwards and a little outwards to their short tendon of insertion, which is closely blended with that of the abductor minimi digiti. A few of the deeper fibres end in the metatarsal bone.

Nerve-supply.—From the external plantar nerve by a branch which enters the under surface of the muscle.

Action.—To flex and slightly abduct the first phalanx of the little toe.

Relations.—Superficially, the flexor longus digitorum and abductor minimi digiti; deeply, the interossei of the outermost interspace.

Variations.—The insertion upon the metatarsal bone may form a separate muscle, the opponens digiti pedis quinti, or it may be entirely absent.

Fourth Layer

The fourth layer consists of the seven interosseous muscles.

INTEROSSEI

The **interossei**—named from their position between the metatarsal bones—are, like those of the hand, seven in number, three being plantar and four dorsal. The **plantar** are small and narrow fusiform bundles; the **dorsal** are bipenniform and of a somewhat broader fusiform shape than the plantar. The interossei of the foot differ from those of the hand in the fact that they adduct and abduct with respect to a longitudinal axis through the line of the second toe; whereas in the hand the median line passes through the middle finger.

The **plantar interossei.**—**Origin.**—(1) The inner and lower surfaces of the three outer metatarsal bones; (2) the adjacent part of the sheath of the peroneus longus tendon.

Insertion.—(1) The inner side of the bases of the first phalanges of the three outer toes; (2) the inner border of the expansions of the long extensor tendons on the back of the first phalanges of the same toes.

The **dorsal interossei** arise from the adjacent surfaces of the metatarsal bones bounding each interosseous space. The first dorsal interosseous, however, differs somewhat in its internal head, which is from the base only of the first metatarsal bone and the adjacent outer surface of the internal cuneiform bone.

Insertion.—The first dorsal interosseous is inserted into:—(1) the inner side of the base of the first phalanx of the second toe; (2) the inner edge of the aponeurosis of the extensor tendon upon the back of the first phalanx. The second, third, and fourth are inserted respectively into:—(1) the outer sides of the bases of the first phalanges of the second, third, and fourth toes; (2) the outer borders of the extensor tendons upon the backs of the same phalanges.

Structure.—The plantar interossei are penniform muscles consisting of fleshy fibres which run forwards to the outer side of a tendon which begins about the middle of the space and becomes free opposite the heads of the metatarsal bones.

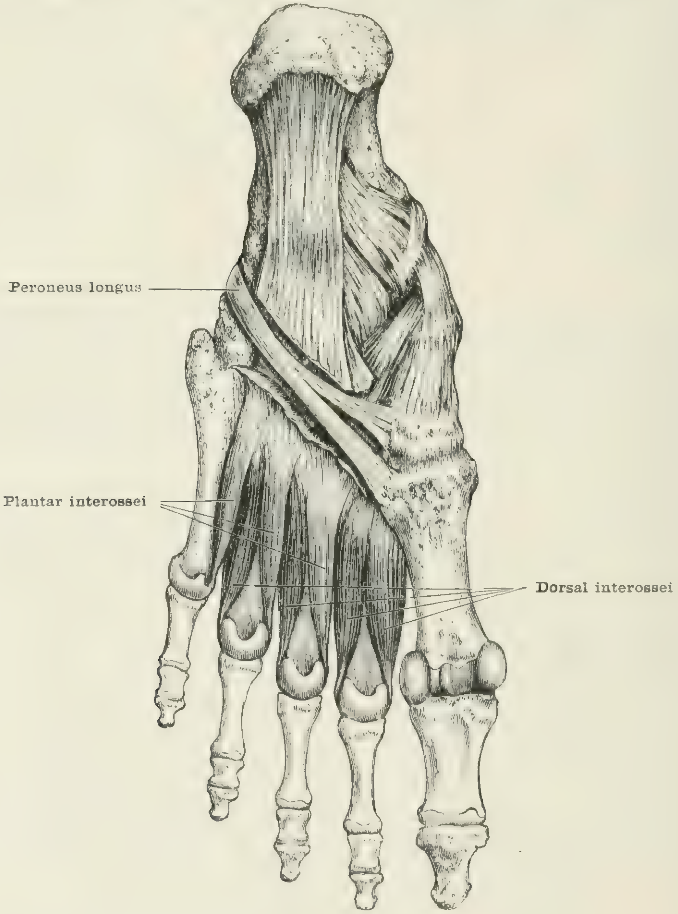
The dorsal interossei are bipenniform, and consist of fleshy fibres which converge from both sides of the space upon a central tendon which begins about the middle of the interosseous space and becomes free opposite the heads of the metatarsal bones. The tendons of both sets of muscles before their insertion lie above the deep transverse metatarsal ligament which separates them from the tendons of the lumbricales. On the dorsum of the foot the dorsal interossei are alone visible; in the sole of the foot both sets are seen.

Nerve-supply.—From the external plantar nerve by filaments which enter the plantar aspect of the muscles, somewhat behind the middle of the interosseous space.

Action.—The common action of all the interossei is (1) to flex the first phalanges of the four outer toes; (2) to extend the second and third phalanges. In these two movements they are assisted by the lumbricales. In walking, this movement is of great importance, as it keeps the toes straight when the weight of the body rests upon the front part of the foot. When these movements are paralysed, the action of the long and short flexors of the toes is to curl them up, and the ends of the toes are subjected to considerable pressure, which may set up inflammation in the beds of the nails.

The special action of the **plantar interossei** is to adduct the first phalanges of the three outer toes; and of the **dorsal interossei** to abduct the second, third, and fourth toes from the middle line of the second toe. As the second toe can be abducted from its own middle line in two directions, it of course requires two abductors.

Fig. 296.—Fourth Layer of the Muscles of the Sole.



Relations.—On the plantar surfaces both sets of interossei are in contact with the muscles of the third layer, and with the external plantar vessels and nerve; on the dorsal surface the dorsal interossei are covered by the tendons of the extensor longus and brevis digitorum. The dorsalis pedis and other perforating arteries pass through the back of the interosseous spaces between the double origins of the dorsal interossei.

MUSCLES OF THE FRONT OF THE LEG

Between the anterior border of the tibia and the anterior of the two external intermuscular septa, are placed four muscles: the tibialis anticus, the extensor proprius hallucis, the extensor longus digitorum, and the peroneus tertius.

1. TIBIALIS ANTICUS

The **tibialis anticus**—named from its attachment to the tibia and its position in the front of the leg—is fusiform and somewhat flattened, with a long terminal tendon.

Origin.—(1) Part of the under surface of the outer tuberosity of the tibia; (2) the outer surface of the upper two-thirds of the tibia; (3) the adjacent part of the anterior surface of the interosseous membrane; (4) the posterior surface of the upper part of the deep fascia of the leg; (5) an intermuscular septum which separates it from the extensor longus digitorum in the upper third of the leg.

Insertion.—The lower part of the front of the inner surface of the internal cuneiform bone and the adjacent part of the base of the first metatarsal bone.

Structure.—A strong penniform muscle the fibres of which, arising fleshy from the bone and the fasciæ, pass forwards and most of them somewhat outwards to be attached to the deep surface and outer border of a tendon, which, beginning below the middle of the leg, becomes free of fleshy fibres two or three inches (5 to 8 cm.) above the ankle-joint; and, after passing first beneath the upper portion of the anterior annular ligament, then partly under and partly over the lower portion, expands slightly to be inserted upon the inner margin of the foot. In passing over the instep it turns upon itself so that its anterior surface becomes below internal.

Nerve-supply.—From the anterior tibial division of the external popliteal nerve by branches which enter the upper third of the muscle upon the outer part of its deep aspect.

Action.—(1) To flex the ankle-joint; (2) to draw upwards the inner border of the foot and so invert the sole; (3) to adduct the front portion of the foot. The first of these movements will be performed chiefly at the ankle-joint; the second and third at the medio-tarsal and calcaneo-astragaloid joints. This muscle is of great importance in walking, as it raises the anterior part of the foot and so enables the toes to clear the ground when the leg is swinging forwards to begin another step.

Relations.—Superficially, the deep fascia; on the outer side, the extensor longus digitorum and extensor proprius hallucis with the anterior tibial vessels and nerve; deeply, the interosseous membrane and the tibia. The tendon lies in a special synovial sheath beneath the two portions of the anterior annular ligament, and upon the ankle-joint and inner bones of the tarsus. A small bursa separates the tendon from the upper part of the inner surface of the internal cuneiform bone.

Variations.—A small tendon is sometimes sent to the head of the first metatarsal bone, the base of the first phalanx of the great toe, or to the fascia covering the instep.

2. EXTENSOR PROPRIUS HALLUCIS

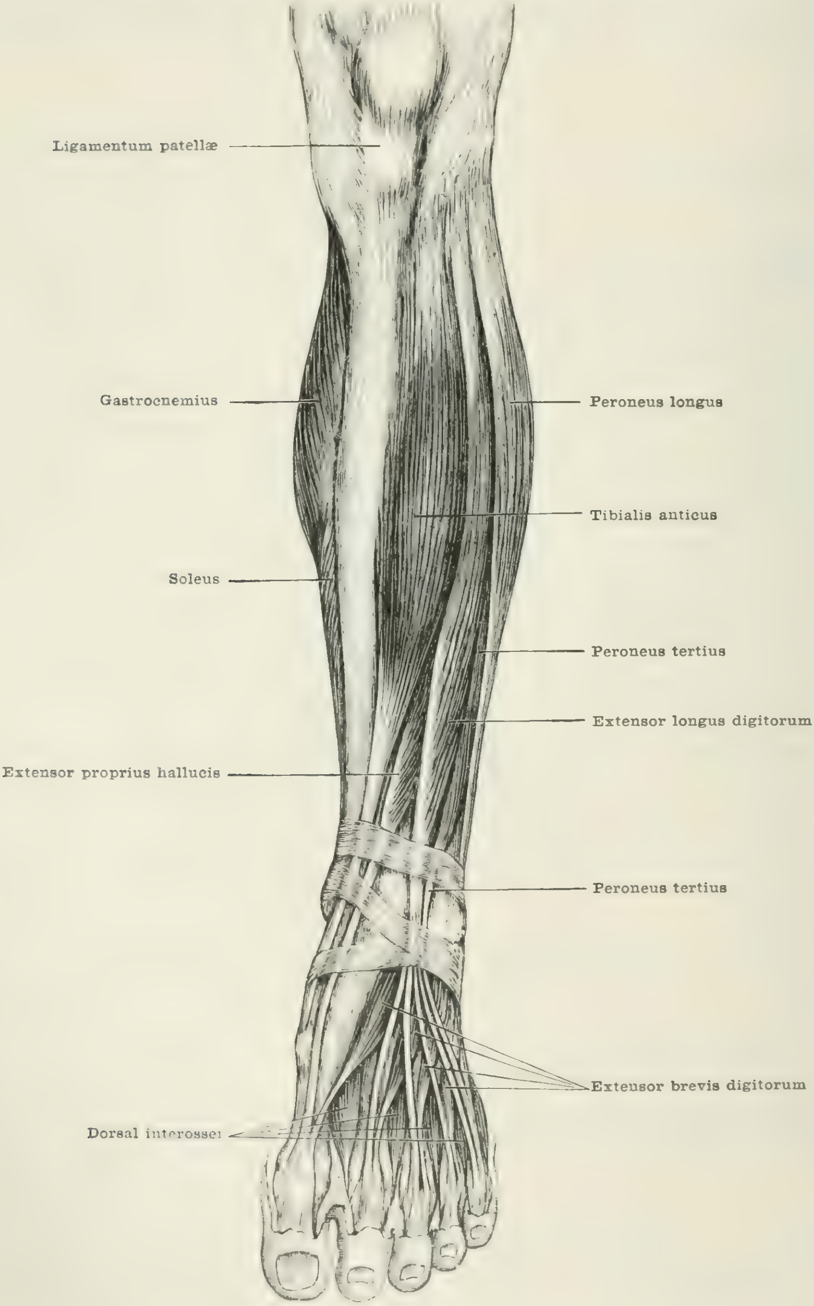
The **extensor proprius hallucis**—named from its being the special extensor belonging to the great toe (*proprius* = peculiar to)—is a somewhat triangular sheet.

Origin.—(1) The middle two-fourths of the anterior (or extensor) surface of the fibula external to the attachment of the interosseous membrane; (2) the adjacent portion of the anterior surface of the interosseous membrane.

Insertion.—(1) The ligamentous structures at the back and sides of the first metatarso-phalangeal joint; (2) the dorsal aspect of the base of the second phalanx of the great toe.

Structure.—Arising by fleshy fibres from the bone and interosseous membrane,

FIG. 297.—THE MUSCLES OF THE FRONT OF THE LEG.


Ligamentum patellæ
Gastrocnemius
Peroneus longus
Tibialis anticus
Soleus
Peroneus tertius
Extensor longus digitorum
Extensor proprius hallucis
Peroneus tertius
Extensor brevis digitorum
Dorsal interossei

the muscle is inserted in a penniform manner into a tendon which appears about the middle of the leg upon its inner and front aspect, and becomes clear of muscular fibres about the level of the ankle-joint. The tendon after passing beneath the upper part of the anterior annular ligament is included in a special sheath beneath the lower part of the same ligament. Opposite the first metatarso-phalangeal joint, it gives off from its sides and under surface bands of connective tissue which unite partly with the two lateral ligaments, especially the internal one, and partly with the periosteum upon the sides of the first phalanx. The rest of the tendon is flattened out and fits closely to the dorsal aspect of the first phalanx; it is finally attached to the second phalanx in a transverse line which crosses the upper surface of its base.

Nerve-supply.—From the anterior tibial by filaments which enter the inner and deeper aspect of the muscle about the middle of the leg.

Action.—(1) To extend the first phalanx of the great toe; (2) slightly to extend the second phalanx, but this movement is chiefly performed by the small muscles of the sole of the foot, which give off expansions to be attached to the borders of the tendon at the sides of the first phalanx; (3) to flex the ankle, and at the same time it will slightly adduct the front of the foot and invert the sole. When the muscle contracts strongly it will hyper-extend the first phalanx, and at the same time flexion of the second phalanx will be produced by the resistance of the flexor longus hallucis tendon.

Relations.—Superficially, the deep fascia, the tibialis anticus, and the extensor longus digitorum; internally, the tibialis anticus; externally, the extensor longus digitorum; deeply, the interosseous membrane, the tibia, and the anterior tibial vessels and nerve. The tendon lies beneath the two portions of the anterior annular ligament, and after crossing the anterior tibial artery near the ankle-joint it runs to its insertion with the dorsalis pedis artery and the innermost tendon of the extensor brevis digitorum on its outer side.

Variations.—The muscle is occasionally divided, and a smaller external portion joins the first tendon of the extensor brevis digitorum, or is inserted separately into the head of the first metatarsal bone or the base of the first phalanx.

3. EXTENSOR LONGUS DIGITORUM PEDIS

The **extensor longus digitorum**—named from its length and its action upon the toes—is fusiform and somewhat flattened, with a four-divided tendon.

Origin.—(1) The outer part of the under surface of the external tuberosity of the tibia; (2) the upper three-fourths of the anterior or extensor surface of the fibula; (3) the outer border of the anterior surface of the interosseous membrane in its upper third; (4) the posterior surface of the deep fascia of the leg; (5) the intermuscular septa which separate it from the upper part of the tibialis anticus and from the long and short peronei.

Insertion.—The three phalanges and the metatarso-phalangeal joints of each of the four outer toes.

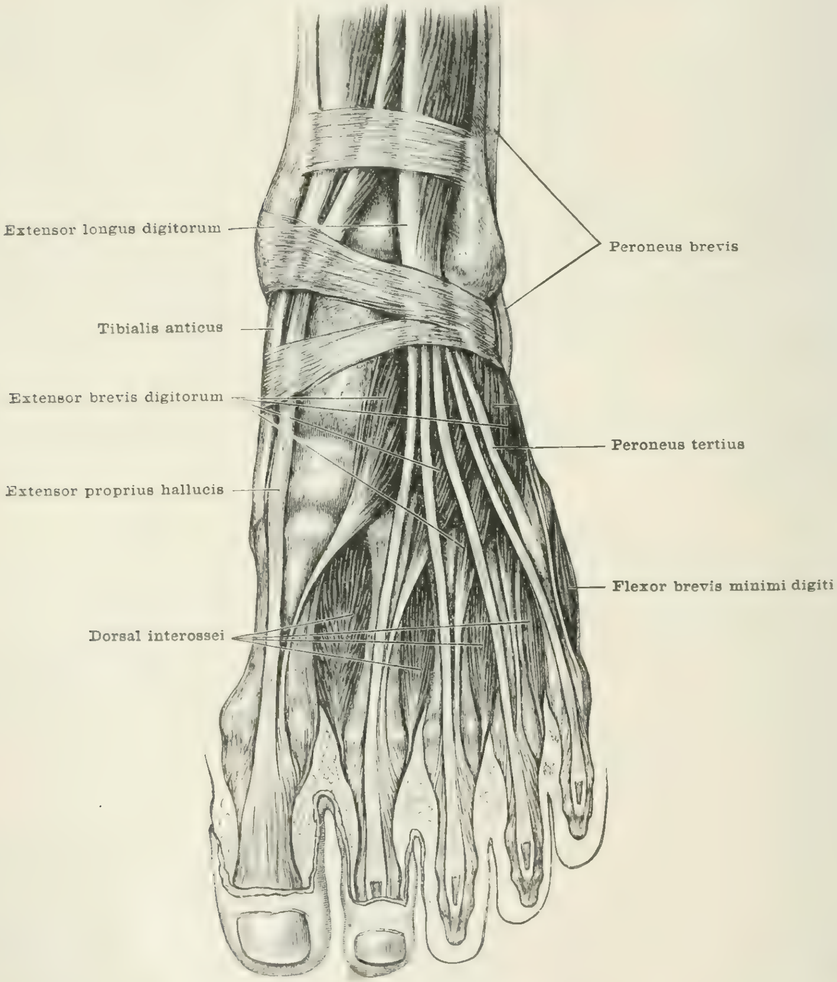
Structure.—This is a penniform muscle, and its fibres arise fleshy from the bones and the fasciæ, and pass forwards and inwards to the back and outer side of the long tendon of insertion. This begins about the middle of the leg, and becomes free from fleshy fibres about the level of the ankle-joint; it passes behind the upper part of the anterior annular ligament, but not in a special synovial sheath; then beneath the lower part of the anterior annular ligament in a special synovial sheath with the peroneus tertius. At this point it divides into four tendons, which diverge upon the back of the foot to the bases of the four outer toes. Each tendon first gives off some strong fibres, which blend with the lateral ligaments of the metatarso-phalangeal articulation, and with the periosteum along the borders of the first phalanx. It then forms a broad expansion covering the back of the first phalanx, and divides into three parts: the central part is inserted into the dorsal aspect of the base of the second phalanx; and the two lateral parts pass forwards with a slight convergence upon the back of the second phalanx to be inserted into the dorsal aspect of the base of the third phalanx.

Nerve-supply.—From the anterior tibial by filaments which enter the deep aspect of the muscle in its upper third.

Action.—(1) To extend the first phalanges of the four outer toes. It has some influence upon the second and third phalanges, but the distal part of its tendon is acted upon chiefly by the short muscles in the sole of the foot, which are attached to the border of the expansion upon the first phalanx. When the muscle contracts to its fullest extent, the first phalanges are extended, while the second and third phalanges are somewhat flexed by the long and short flexors. (2) To flex the ankle-joint. (3) Slightly to abduct and evert the front part of the foot.

Relations.—Superficially, the deep fascia of the leg and the anterior annular ligaments; on its inner side, the tibialis anticus and extensor proprius hallucis, the anterior tibial vessels and nerve with their continuations in the foot. Externally, the peroneus longus and brevis, the musculo-cutaneous nerve, and, lower down, the peroneus tertius. Behind, the anterior tibial nerve above, and the ankle-joint, tarsal and metatarsal bones, and the extensor brevis digitorum below.

FIG. 298.—THE MUSCLES OF THE DORSUM OF THE FOOT.


Extensor longus digitorum
Peroneus brevis
Tibialis anticus
Extensor brevis digitorum
Peroneus tertius
Extensor proprius hallucis
Flexor brevis minimi digiti
Dorsal interossei

Variations.—The muscle may be divided nearly up to its origin. It may give off slips to the extensor proprius hallucis, extensor brevis digitorum, or one of the interossei. Sometimes also it has an insertion into some of the metatarsal bones.

4. PERONEUS TERTIUS

The **peroneus tertius**—named from περόνη, the fibula, and called *tertius* because it is the third of the muscles which pass from the fibula to the metatarsus—is a small triangular sheet which is closely blended with the preceding muscle.

Origin.—(1) The lower fourth of the anterior (or extensor) surface of the fibula; (2) the front of the interosseous membrane for a short distance above the ankle-joint; (3) the external intermuscular septum and the deep fascia of the leg.

Insertion.—The upper part of the base of the fifth metatarsal bone.

Structure.—Arising fleshy, the muscular fibres pass downwards and inwards in penniform fashion to a tendon which appears on the inner border of its anterior surface. It becomes free from fleshy fibres at the level of the ankle-joint, and after passing beneath the upper part of the anterior annular ligament, it is included with the extensor longus digitorum in a special synovial sheath beneath the lower part of the ligament, and finally diverges from it to be inserted into the inner part of the upper surface of the base of the fifth metatarsal bone.

Nerve-supply.—Unlike the other peronei, which are supplied by the musculo-cutaneous nerve, it receives filaments from the anterior tibial which enter the inner and deep aspect of the muscle in the upper part of its course.

Action.—(1) To flex the ankle-joint; (2) to abduct the anterior part of the foot; (3) slightly to elevate the outer border of the foot and so to produce eversion of the sole.

Relations.—Superficially, the anterior annular ligament and branches of the musculo-cutaneous nerve; on the inner side, the extensor longus digitorum, of which it is really a subdivision; on the outer side, the peroneus brevis; deeply, the ankle and outer tarsal joints with the extensor brevis digitorum.

Variations.—The peroneus tertius is often closely blended with the extensor longus digitorum. It is sometimes wanting, and replaced by a slip of tendon from the extensor longus digitorum. Occasionally it sends slips of tendon to the expansion of the extensor longus digitorum on the first phalanx of the two outer toes, or to the fourth dorsal interosseous.

MUSCLE ON THE DORSUM OF THE FOOT

This consists of the four bellies of one muscle—the extensor brevis digitorum.

EXTENSOR BREVIS DIGITORUM PEDIS

The **extensor brevis digitorum**—named from its being the shorter of the two muscles which extend the toes—is a triangular sheet which breaks up in front into four small divisions.

Origin.—(1) The outer part of the upper surface of the great process of the calcaneum; (2) the interior of the loop of fascia which forms the outer part of the lower anterior annular ligament.

Insertion.—By four tendons into the four inner toes; the innermost is attached to the outer border of the upper surface of the first phalanx of the great toe near its base; the three other tendons to the outer border of the tendons of the extensor longus digitorum just in front of the bases of the first phalanges.

Structure.—Arising superficially by fleshy, and on the deep surface by short tendinous fibres, the muscle diverges inwards and forwards, and soon divides into four fleshy bellies, of which that to the great toe is the largest and most separate. Each portion has a bipenniform arrangement, with its central tendon upon the dorsal surface, and becoming free opposite the middle of the metatarsus.

Nerve-supply.—From the anterior tibial nerve by small filaments which enter the deep surface of the muscle near its inner border as it crosses the cuboid and external cuneiform bones.

Action.—(1) To extend the four inner toes. In the case of the outer toes the two last phalanges will be chiefly extended, and the obliquity of its insertion, by causing it to draw the toes somewhat outwards at the same time that it extends them, will enable it to correct the opposite tendency of the long extensor. (2) The innermost tendon will act as an adductor of the first phalanx of the great toe.

Relations.—Superficially, the tendons of the extensor longus digitorum and peroneus tertius; deeply, the tarsal and tarso-metatarsal joints; and, in the case of the tendon to the great toe, the dorsalis pedis vessels and the termination of the anterior tibial nerve.

Variations.—The number of tendons may be diminished or increased. Sometimes a tendon is given to the little toe. Accessory bundles may be derived from some of the tarsal or metatarsal bones, and slips have been found running to the dorsal interossei; and also a small slip between the first and second bellies, going to the inner side of the second toe or its metatarsal bone.

MUSCLES ON THE OUTER SIDE OF THE LEG

These are two muscles—the peroneus longus and brevis—situated upon the outer side of the fibula in a compartment of quadrilateral section, bounded internally by the fibula, in front and behind by intermuscular septa, and externally by the deep fascia of the leg.

1. PERONEUS LONGUS

The **peroneus longus** (figs. 292 and 296)—named from its being the longer of the two fibular muscles—is long and fusiform.

Origin.—(1) The outer tuberosity of the tibia by a few fibres; (2) the front of the head of the fibula; (3) the upper two-thirds of the outer (or peroneal) surface of the fibula, occupying the whole of this surface above, and the posterior half of it below; (4) the inner surface of the deep fascia of the leg, and the opposed surfaces of the two external intermuscular septa.

Insertion.—(1) The lower part of the outer surface of the base of the first metatarsal bone; (2) the lower part of the outer surface of the internal cuneiform bone close to its articulation with the first metatarsal bone.

Structure.—This is a strong penniform muscle, the short fleshy fibres of which pass downwards, and for the most part forwards, to be inserted into the tendon which, beginning about three inches (7·5 cm.) below the head of the fibula, runs along the front of the outer surface of the muscle, and becomes free in the lower third of the leg. It then passes behind the outer ankle, beneath the external annular ligament, in a special sheath with the tendon of the peroneus brevis, which lies in front of it. On the outer surface of the calcaneum, it runs forwards and downwards in a special compartment of the external annular ligament below the companion tendon. At the outer border of the foot it again changes its direction, and passes obliquely inwards and forwards across the sole of the foot, in a canal formed by the long plantar ligament beneath, and by the groove in the cuboid bone above, to its insertion near the inner side of the sole. In the upper two-thirds of the leg the peroneus longus almost entirely conceals from view the peroneus brevis, which lies beneath and slightly anterior to it.

The synovial tube which it enters at the outer ankle is common to it and the peroneus brevis, and bifurcates to accompany the two tendons where they are separated by the peroneal tubercle of the os calcis. A second sheath envelopes the tendon in the sole, and where the tendon enters this canal it often contains a sesamoid bone which plays upon the front of the ridge of the cuboid bone.

Nerve-supply.—From the musculo-cutaneous branch of the external popliteal nerve by filaments which enter the deep and posterior aspect of the muscle in its upper third.

Action.—(1) To extend the ankle-joint; (2) to abduct the anterior part of the foot; (3) to depress the inner border of the foot, and so to evert the sole; (4) by drawing backwards and outwards the base of the first metatarsal bone, it tends to render more concave the antero-posterior and transverse arches of the foot. In the former action it assists the tibialis posticus and flexor longus hallucis.

In walking, it will act with the gastrocnemius and soleus in lifting the heel from the ground, and its tendency to evert the sole and abduct the foot will counteract the opposite tendency of the muscles attached to the tendo Achillis. Moreover, the tendency of this latter set of muscles is to press the outer part of the ball of the toes firmly upon the ground. On the other hand, the influence of the peroneus longus in extending the foot is especially exerted upon the ball of the great toe. By the combined action of all these extensors of the ankle the whole of the ball of the foot is pressed evenly upon the ground and firmness of tread secured.

Relations.—Superficially, the deep fascia, the external annular ligament; and in the sole, the abductor minimi digiti, the adductor hallucis, and long plantar ligament; in front, the peroneus brevis, the extensor longus digitorum, and the musculo-cutaneous nerve; behind, the soleus and flexor longus hallucis; deeply, the external popliteal nerve which occupies a fibrous canal below the head of the fibula, the ankle-joint, calcaneum, cuboid, and the bases of the second and third metatarsal bones.

Variations.—Sometimes a second peroneus arises between the peroneus longus and brevis, and sends its tendon to join that of the peroneus longus. A slip may be given to the external annular ligament. The insertion of the muscle may extend to the bases of the adjacent metatarsal bones.

2. PERONEUS BREVIS

The **peroneus brevis** (figs. 292 and 298)—named from its being the shorter of the two fibular muscles—is also a triangular sheet.

Origin.—(1) The lower two-thirds of the outer (or peroneal) surface of the fibula; (2) the deep fascia of the leg and the intermuscular septa in front and behind.

Insertion.—(1) The outer part of the base of the fifth metatarsal bone; (2) the outer border of the expansion of the tendon of the extensor longus digitorum upon the first phalanx of the little toe.

Structure.—This is also a penniform muscle. The short fibres pass obliquely downwards to the tendon which lies upon the outer surface of the muscle. It becomes free from fleshy fibres just above the external malleolus where it passes beneath the external annular ligament in the same sheath with the peroneus longus tendon, and after changing its direction, runs forwards and somewhat downwards upon the outer surface of the calcaneum and above the peroneal tubercle.

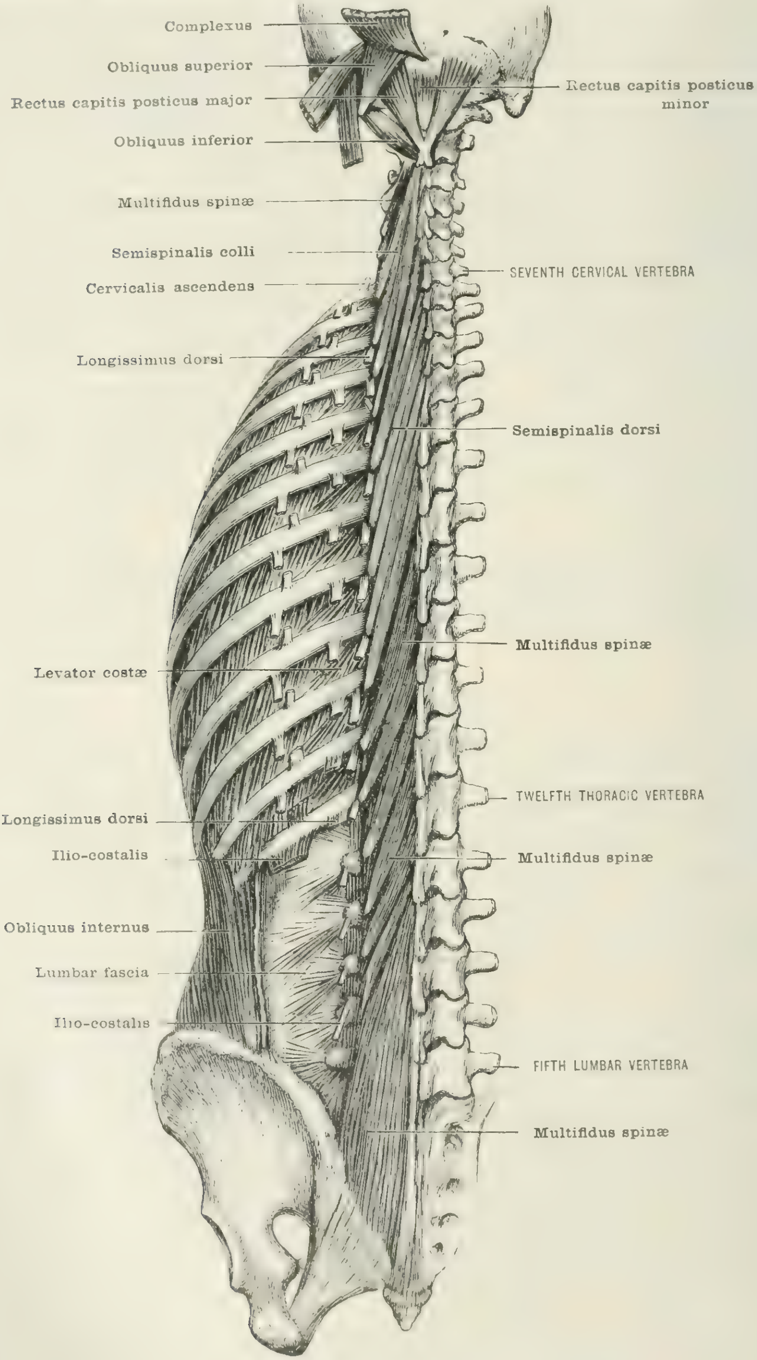
Nerve-supply.—The musculo-cutaneous branch of the popliteal nerve by filaments which enter the deep aspect of the muscle about the middle of the leg.

Action.—(1) Slightly to extend the ankle; (2) to abduct the anterior part of the foot; (3) slightly to elevate the outer border of the foot, and so evert the sole.

Relations.—Superficially, the peroneus longus, deep fascia of the leg and external annular ligament; in front, the extensor longus digitorum and peroneus tertius; behind, the peroneus longus and flexor longus hallucis; deeply, the ankle-joint, calcaneum, and cuboid bones.

Variations.—The small slip which the tendon sends on to the expansion upon the little toe may be wanting, or it may be inserted into the first or even the second phalanx. This slip may be entirely separate, so as to form a fourth peroneus.

FIG. 299.—THE EXTERNAL INTERCOSTALS AND LEVATORES COSTARUM.


Complexus
Obliquus superior
Rectus capitis posticus major
Obliquus inferior
Rectus capitis posticus minor
Multifidus spinæ
Semispinalis colli
Cervicalis ascendens
SEVENTH CERVICAL VERTEBRA
Longissimus dorsi
Semispinalis dorsi
Multifidus spinæ
Levator costæ
TWELFTH THORACIC VERTEBRA
Longissimus dorsi
Ilio-costalis
Multifidus spinæ
Obliquus internus
Lumbar fascia
Ilio-costalis
FIFTH LUMBAR VERTEBRA
Multifidus spinæ

THE MUSCLES OF THE THORAX

These consist of six muscles, or sets of muscles, which are attached chiefly to the ribs, their cartilages, and the sternum: viz. the external and internal intercostals, the levatores costarum, the triangularis sterni, infracostales (or subcostales), and diaphragm.

INTERCOSTAL MUSCLES

The **intercostal muscles**—named from their position—are long narrow sheets of short oblique muscular fibres which occupy the intercostal spaces. The fibres of the outer sheet run downwards and forwards, and those of the inner downwards and backwards; and the two sheets are the upper continuations of the obliquus externus and internus of the abdominal wall.

1. THE EXTERNAL INTERCOSTALS

The **external intercostals,** which are stronger than the internal, are eleven in number, and fill the spaces between the ribs from the tubercle to the tip. In the higher spaces, however, they do not come quite so far forwards as below. Above, the lower attachment barely reaches the tip of the rib; while below, the upper attachment reaches the tip, and the lower is upon the cartilage.

Origin.—The lower or outer border of all the ribs except the last, from tubercle to anterior extremity.

Insertion.—The outer aspect of the upper border of all the ribs but the first from a little in front of the tubercle to the tip, or in the lower ribs for a short distance upon the cartilage.

Structure.—Composed of obliquely directed parallel bundles of fleshy fibre, with a short tendinous origin, and with a slight admixture of fibrous tissue. The posterior are more oblique than the anterior fibres. The sheet formed by their fibres is thickest behind, and becomes gradually thinner forwards. Between the cartilages it is succeeded by a thin membrane, the **external intercostal fascia,** which is composed of fibres running with the same slope as those of the muscle.

Nerve-supply.—The intercostal nerves as they run forwards give numerous filaments to the inner surfaces of the muscles.

Action.—See later.

Relations.—Superficially, the pectoralis major and minor, the serratus magnus, the external oblique, the latissimus dorsi, the trapezius, rhomboidei, the serrati postici, the continuation upwards of the erector spinae, and the levatores costarum: deeply, the internal intercostals and infracostales, the intercostal vessels and nerves.

2. THE INTERNAL INTERCOSTALS

The **internal intercostals** are eleven in number, and fill the spaces from the angles of the ribs to the anterior extremities of the cartilages. The fibres, which are shorter and not quite so oblique as those of the outer sheet, are directed downwards and backwards.

Origin.—The upper border of the subcostal groove of the eleven upper ribs from the angle forwards, and the continuation of this border upon the cartilages.

Insertion.—The inner aspect of the upper border of the eleven lower ribs and cartilages.

Structure.—The sheets are thicker in front. There is less fibrous tissue mixed with the fleshy fibres than in the outer sheet. In the upper and lower spaces the fleshy fibres are continued a little further back than the angles. The rest of the space behind the thin posterior border of the sheet is filled by a thin membrane composed of fibres running in the same direction, and is called the **internal intercostal fascia.**

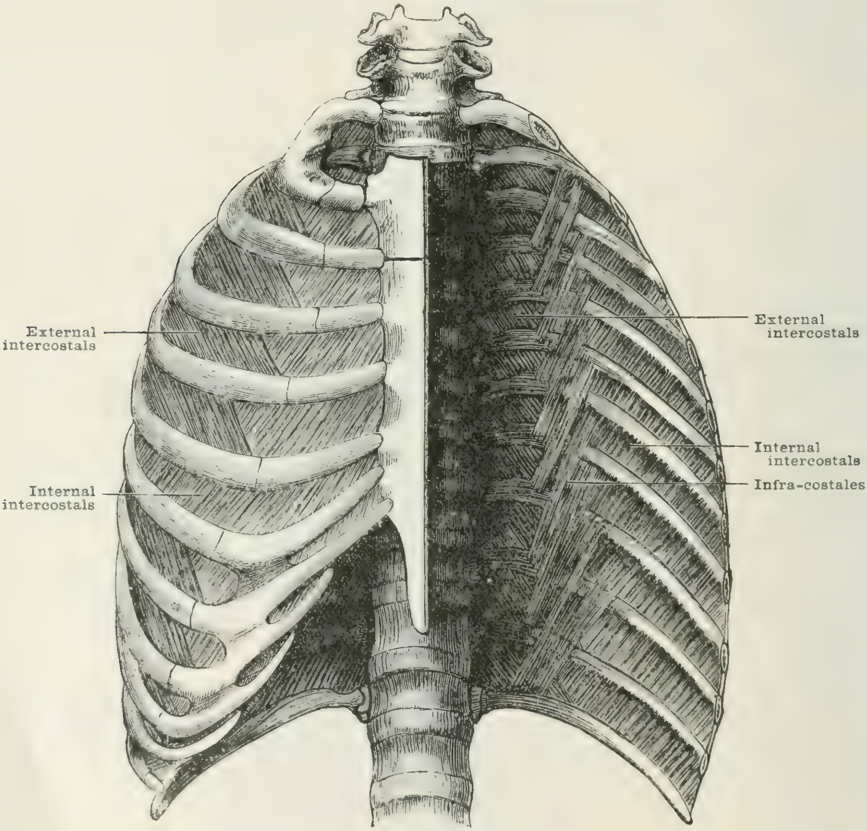
Nerve-supply.—Branches from the intercostal nerves, which are supplied to its outer surface or are given off where the nerves are concealed in the interior of the muscle.

Action.—See below.

Relations.—Superficially, the external intercostal muscles, and the intercostal arteries and nerves; deeply, the triangularis sterni, infracostales, diaphragm, and the pleura.

The *action of the intercostal muscles* generally is to approximate the ribs to one another, and they are chiefly used in inspiration. The obliquity of their fibres enables them with a small contraction to produce a greater approximation than if they ran perpendicularly between the ribs (page 287). Moreover, if the fibres were all directed, like those of the outer sheet, downwards and forwards, there would be a tendency for the lower ribs to be drawn backwards as well as upwards in inspiration; and if, on the other hand all the fibres were directed downwards and backwards like those of the inner sheet, the tendency would be for the lower ribs to be drawn forwards as well as upwards in inspiration. The combined action of the two sets produces the direct elevation of the ribs, the forward pull of the inner sheet being counteracted by the backward pull of the outer sheet. If the external intercostals were carried forwards as far as the sternum, they would tend to take the sternum as a fixed point and to depress the anterior extremities of the ribs. A similar result would follow the continuation backwards of the internal intercostals to the vertebral

FIG. 300.—THE INTERCOSTAL MUSCLES.



column. It will be also noticed that the front part of the external, and the back part of the internal intercostal sheets are thin and weak, so as to diminish this tendency towards an expiratory movement. It has been urged that both sets of intercostals cannot approximate the ribs, as in inspiration some of the intercostal spaces are seen to open out and become wider. To this it may be replied that, whatever happens in some of the spaces, it is certain that the general tendency is that of approximation of the ribs, and diminution of the intervals between them, as after a full inspiration the last rib is nearer to the first rib. Moreover, it does not always follow that because a muscle is lengthening it is not acting (cf. such cases as that of the long head of the triceps when it is used in extending the elbow during the elevation of the arm). If when most of the ribs are being approximated it should happen that some of the spaces are found to be widened, the action of the muscle in these widened spaces will probably be to prevent a greater separation, and by steadying the lower ribs to enable the muscles which descend from them to act. When the lowest rib is fixed by the quadratus lumborum and other muscles, it is probable that the intercostals, at any rate those of the lower spaces, by approximating the lower ribs to the last rib, may act as muscles of expiration. The following are some of the arguments which may be adduced in support of the view that both sets of intercostals act together, and also that their action is usually inspiratory.

1. The advantage already mentioned, from their oblique decussation enabling them to approximate the ribs more completely and at the same time to elevate them directly when they act in combination (cf. the action of the external and internal oblique in approximating the last rib to the crest of the ilium).

2. Muscles supplied by the same nerve are rarely antagonistic.

3. In long-standing paralysis of the intercostals the sternum is depressed, the chest flattened, and kept in a permanent condition of exaggerated expiration.

4. Galvanism of the intercostals produces expansion of the chest. In Duchenne's experiment he found that when he galvanised so slightly as only to affect the external intercostals, the inspiratory movement was small; but when he galvanised so strongly as to affect the nerve, and through the nerve the internal intercostals—as was known by the contraction of muscular fibre being felt between the cartilages of the ribs, in which situation the only fleshy fibres are those of the inner set—a strong inspiratory movement was produced.

From the peculiar shape of the ribs and the mode of their articulation, their elevation is accompanied by a rotation of the arcs formed by them upon their chords so that their planes from a sloping attain an almost horizontal position. Hence the widening of the chest during inspiration, in addition to its expansion from before backwards due to the forward elevation of the tips of the ribs.

3. LEVATORES COSTARUM

The **levatores costarum** (fig. 299)—named from their action, as elevators of the ribs—are twelve triangular sheets, which cover the back part of the intercostal spaces, and are continuous with the fibres of the external intercostal muscles.

Origin.—The tips of the transverse processes of the last cervical, and all the thoracic vertebræ except the last.

Insertion.—The outer surface of the ribs from the tubercle to the angle.

Structure.—Arising by short tendinous fibres the muscle expands in a fan shape, and is attached to the next rib below. Frequently fibres pass over one rib and are inserted upon the next but one.

Nerve-supply.—The intercostal nerves which send branches to their deep surfaces.

Action.—To elevate the ribs in inspiration.

Relations.—Superficially, the outer and upward continuations of the erector spinæ; deeply, the external intercostals, which are continuous with the outer border of the muscles.

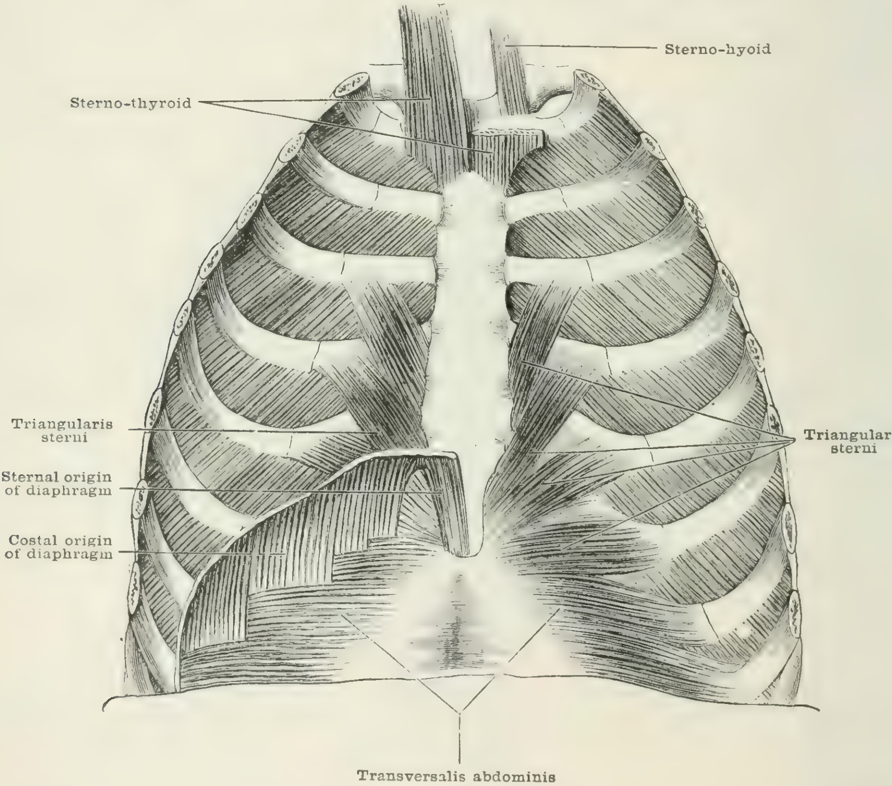
4. TRIANGULARIS STERNI

As the external and internal oblique muscles of the abdomen are represented by the external and internal intercostals in the thorax, so also the transversalis abdominis has its counterpart in the thin stratum of muscular fibre at the sides of the sternum called the triangularis sterni, and the still thinner expansion behind of the infracostales.

The **triangularis sterni**—named from its shape and its connection with the sternum—is a thin, musculo-membranous, triangular sheet, with the apex below and directed internally, while the serrated base is external.

Origin.—(1) The side of the lower third of the back of the sternum; (2) the upper and lateral part of the back of the ensiform cartilage; (3) the back of the inner ends of the fifth, sixth, and seventh costal cartilages.

FIG. 301.—THE MUSCLES ATTACHED TO THE BACK OF THE STERNUM.



Insertion.—The outer ends of the posterior surfaces and lower borders of the cartilages of the second or third to the sixth ribs, and occasionally the tips of the ribs also.

Structure.—The muscle is membranous at its origin and insertion, and it contains many bands of fibrous tissue. Its fibres diverge fanwise, the lower ones being horizontal, and in serial continuation with the upper digitations of the transversalis abdominis, while its higher fibres run obliquely upwards and outwards.

Nerve-supply.—The upper intercostals, which send filaments to its anterior aspect.

Action.—To depress the anterior extremities of the ribs to which it is attached, and so to help in expiration.

Relations.—In front, the internal intercostals and internal mammary vessels; behind, the pleura and pericardium.

5. INFRACOSTALES

The **infracostales,** or **subcostales**—named from their position beneath the ribs—form a thin musculo-membranous sheet lining the back of the thorax external to the tubercles of the ribs; broader and better developed below, becoming narrower and thinner above. Frequently it consists of only a few bundles of fibres which can be distinguished from the internal intercostals by the fact that they are not confined to one intercostal space.

Origin.—The lower part of the inner surface of the ribs near their angles.

Insertion.—The upper part of the inner surface of the ribs, each bundle of fibres usually passing over one rib to be inserted upon the next higher.

Structure.—The fibres arise tendinous, run upwards and outwards, and have tendinous insertions. The higher fibres run more vertically. The lower approach nearer to the vertebral column, arising from the ribs just external to their tubercles.

Nerve-supply.—The intercostal nerves, which enter their outer surface.

Action.—To depress the ribs, and assist in expiration.

Relations.—Externally, the external and internal intercostal muscles; internally, the parietal layer of the pleura, which is separated from them by a thin aponeurosis sometimes called the **endothoracic fascia.**

6. THE DIAPHRAGM

The **diaphragm**—named from its function as the *διάφραγμα*, or partition wall between the thorax and abdomen—is a dome-shaped musculo-membranous sheet of a kidney-shaped outline when seen from above, and consists of a pair of muscles with a lateral origin and a central aponeurotic insertion, resembling the two transversales abdominis, which unite in the linea alba so as also to form a single dome-shaped biventral muscle.

Origin.—By three portions:—

1. **Anterior or sternal portion.**—The lower border and back of the ensiform cartilage, and the adjacent part of the back of the anterior aponeurosis of the transversalis abdominis.

2. **Lateral or costal portion.**—The lower borders and inner surfaces of the cartilages of the six lower ribs, and sometimes also from the adjacent part of the ribs.

3. **Posterior or vertebral portion.**—(1) The **ligamentum arcuatum externum,** a fibrous thickening of the anterior layer of the lumbar fascia, which stretches from the tip of the transverse process of the second lumbar vertebra to the tip of the last rib; (2) the **ligamentum arcuatum internum**—a fibrous thickening of the iliac fascia, which arches over the upper part of the psoas from the side of the body of the second lumbar vertebra to the tip of its transverse process; (3) the **crus** of the diaphragm—a strong vertical band, fleshy externally, tendinous internally—arising on the **right side** from the front of the bodies of the first to the third or fourth lumbar vertebræ, from the intervening vertebral discs, and the anterior common ligament; on the **left side,** from the bodies of the first to the second or third vertebræ only, as well as the discs and anterior common ligament.

Insertion.—The front, sides, and back, of the central tendon.

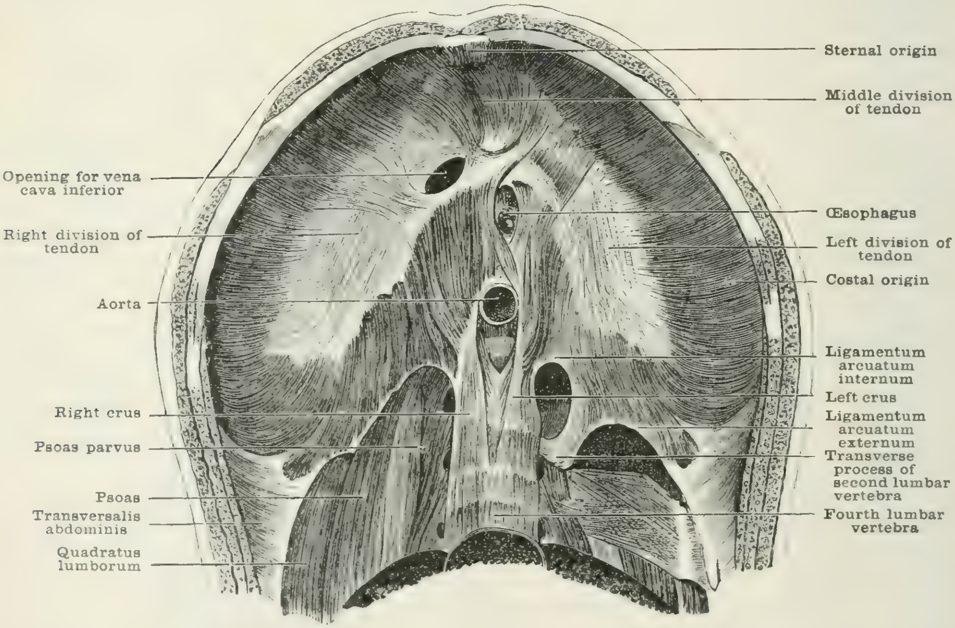
Structure.—The fibres, arising fleshy from their extensive origin, pass at first vertically upwards, and then arch inwards to be attached to the borders of the central tendon. The sternal fibres are the shortest, and they are often separated from the costal portion by a small triangular interval filled with areolar tissue, and giving passage to the superior epigastric vessels. The costal origin forms a series of teeth which do not correspond accurately with the number of ribs, some rib cartilages having two teeth attached to them. They interdigitate with the serrations of the transversalis abdominis (fig. 301). The aponeurotic fibres which form the inner portion of the two crura, after arching in front of the abdominal aorta, are continued by fleshy fibres which decussate, and so changing sides form a loop round the œsophagus before joining the central aponeurosis.

The *central tendon*, or aponeurosis, forms the summit of the dome, and is of a similar outline to the diaphragm, being kidney-shaped, with the concavity behind. It approaches nearer the back than the front of the thorax. There is a slight notching of its outline in front, which divides it into three parts, so that it has somewhat of a trefoil shape, the right leaflet being the largest, and the left the smallest. Its fibres run in many directions.

The diaphragm contains three large foramina, for the passage of the vena cava inferior, œsophagus, and aorta.

Foramina.—Close to the posterior border of the central tendon at the junction of the right and middle leaflet is a quadrilateral opening with rounded angles, the *foramen for the vena cava inferior*, the outer coat of which vessel is blended with its fibrous edges. The *œsophageal opening* is oval, with the long diameter directed forwards. It is surrounded by fleshy fibres, and lies to the left of the middle line, opposite the body of the tenth thoracic vertebra. Through it passes the œsophagus, with the left vagus nerve in front, and the right behind; also a few small œsophageal branches from the thoracic aorta, on their way to join some small œsophageal branches from the gastric artery. The *aortic opening*, formed by the union of the crura, is fibrous, and of oval shape. It is situated in front of the twelfth thoracic vertebra, and is completed behind by the anterior common ligament. Through it pass the aorta, the vena azygos major, and the thoracic duct. In the crura on either side are small openings which allow of the passage of the great splanchnic nerves, and the left crus is usually perforated also by the vena azygos minor.

FIG. 302.—DIAPHRAGM.


Sternal origin
Middle division of tendon
Opening for vena cava inferior
Œsophagus
Right division of tendon
Left division of tendon
Costal origin
Aorta
Ligamentum arcuatum internum
Left crus
Right crus
Ligamentum arcuatum externum
Psoas parvus
Transverse process of second lumbar vertebra
Psoas
Transversalis abdominis
Fourth lumbar vertebra
Quadratus lumborum

Nerve-supply.—The two phrenic nerves, chiefly derived from the cervical plexus of each side through the fourth cervical nerves, break up close to the diaphragm into many filaments, which penetrate the muscular structure near the anterior border of the central tendon, and are distributed to the under surface of the muscle. Sympathetic filaments are also given to it from the plexuses which accompany the phrenic arteries.

Action.—To deepen the chest from above downwards, and so produce a movement of inspiration. The central tendon, especially the middle part of it, which is closely connected by means of the pericardium with the deep fascia of the neck, is but little depressed; but the arched fleshy fibres all around flatten, and so increase greatly the capacity of the sides of the thoracic cavity. At the same time the abdominal viscera are driven downwards, and as the front part of the parietes is the most yielding, they are also displaced forwards, so as to cause a greater prominence of this part of the abdomen. In the expulsive efforts of defecation and parturition, after the diaphragm has first contracted in a deep inspiration, and the glottis has been closed so as to prevent the escape of air from the chest, the abdominal muscles are able to contract with full effect upon the viscera, which have been pressed down by the previous descent of the diaphragm.

The lower six ribs are slightly elevated by the diaphragm, and the hypochondria somewhat dilated, this latter movement being due to the forward and outward pressure of the depressed viscera.

Relations.—Above lie the pleuræ and pericardium, the heart and the lungs. Below are the peritoneum, the liver with its ligaments, the stomach, the spleen, pancreas, kidneys, and suprarenal capsules. The dome-shaped upper convex surface rises higher upon the right than the left side. On the right side, being raised by the liver, it reaches to the level of the junction of the fifth costal cartilage with the sternum, and on the left side only to the level of the junction of the sixth costal cartilage.

Variations.—The œsophageal opening has been found in the right crus, instead of being surrounded by decussating fibres from both crura. The sternal portion of the muscle is not unfrequently absent.

THE ABDOMINAL PARIETES

The superficial fascia covering the walls of the abdomen is continuous with that of the thorax and lower limbs, and is usually divided into two layers.

The first layer is well provided with fat, which in many individuals attains to a considerable thickness, especially in the lower part of the anterior wall.

The second or deep layer (Scarpa's fascia) is of a more membranous character and contains a quantity of elastic fibres. Near the groin it is separated from the more superficial layer by blood-vessels and lymphatic glands. Upon its deeper surface it is loosely connected with the deep fascia which invests the external oblique muscle; but it is closely blended with the linea alba, the fibrous structures in front of the pubic bones, the fascia lata immediately below Poupart's ligament, and the crest of the ilium.

Both layers are continued downwards upon the external genital organs. In the male they lose their fat and blend with the suspensory ligament of the penis, the fascia covering that organ, and the dartos and septum of the scrotum. In the female they are continuous with the superficial fascia of the vulva.

THE ABDOMINAL MUSCLES

The muscular portion of the abdominal wall forms a lozenge-shaped figure of which the vertical diagonal extends from the ensiform process to the symphysis pubis, while the transverse encircles the abdomen from tip to tip of the transverse processes of the third lumbar vertebra.

The boundaries of this muscular wall are formed, above by the costal cartilages of the six lower ribs; behind, by the tips of the transverse processes of the lumbar vertebræ; below, by the crests of the ilia and the pubes. More accurately, each lateral half may be looked upon as a four-sided figure of which the upper boundary slopes backwards and downwards; the lower, backwards and upwards; while the long anterior boundary and short posterior boundary are vertical and parallel. The muscles contained in the parietes may be divided into *vertical* and *transverse*. The former, three in number, are situated two in front, and one behind; while the latter, also three in number, pass transversely, or with some obliquity, between the anterior and posterior boundaries of the space.

The two lateral halves unite in front in a strong fibrous band called the **linea alba**, which stretches from the tip of the ensiform cartilage to the upper part of the symphysis pubis. It is partly formed by vertical fibres stretching between these two points, but chiefly by the interlacement of the transverse and oblique bands of fibrous tissue which pass between the aponeuroses of the muscles upon either side. In its lower two-fifths it is not more than one-eighth of an inch (3 mm.) broad; in its upper three-fifths it is broader, usually not less than a quarter of an inch (6 mm.) in width, but in some bodies it may be stretched to a much greater extent. At the junction of the lower two-fifths and upper three-fifths is the small fibrous ring of the **umbilicus** through which pass the remnants of the fœtal vessels.

ANTERIOR VERTICAL MUSCLES

These are two in number—the pyramidalis and rectus abdominis.

1. PYRAMIDALIS

The **pyramidalis** (fig. 266)—named somewhat fancifully from its triangular shape—is a fan-shaped sheet of muscular fibre forming a right-angled triangle, of which the shortest side corresponds to the origin, and the other side containing the right angle to the linea alba.

Origin.—(1) The front of the pubic crest; and (2) the fibrous structures which cover the front of the body of the os pubis and its symphysis.

Insertion.—The linea alba at a point about half-way between the pubes and the umbilicus.

Structure.—Arising by a short tendinous sheet, the fleshy fibres converge as they pass upwards. Those nearer to the middle line ascend vertically, while those which arise near the pubic spine pass obliquely upwards and inwards to the tendinous insertion of the muscle into the linea alba three or four inches (8 to 10 cm.) above the symphysis pubis.

Nerve-supply.—From the eleventh and twelfth thoracic nerves and from the ilio-hypogastric branch of the lumbar plexus, through their terminal filaments which enter the deep surface of the muscle.

Action.—By its contraction, it pulls upon the linea alba and so upon the lower end of the ensiform cartilage. It will therefore assist the rectus in flexion of the thorax upon the pelvis, or of the pelvis upon the thorax. It can also help feebly to compress the abdominal viscera.

Relations.—Superficially, the aponeuroses of the *transverse* abdominal muscles; deeply, the rectus abdominis, from which it is separated by a thin fibrous lamella.

Variations.—The height to which this muscle extends is variable. It is often absent on one or both sides; or it may be double.

2. RECTUS ABDOMINIS

The **rectus abdominis** (fig. 266)—named from its straight direction—is a strong ribbon-shaped muscle running vertically on either side of the linea alba from the pubes to the ensiform and adjacent costal cartilages.

Origin.—By two tendons: (1) the **outer head** from the whole of the crest of the pubes; (2) the **inner head** crosses the middle line of the body, and arises from the fibrous structures lying in front of the symphysis.

Insertion.—(1) The anterior surface of the tip of the fifth rib; (2) the front of the costal cartilages of the fifth, sixth, and seventh ribs; sometimes also (3) the anterior surface of the base of the ensiform cartilage near its outer border.

Structure.—The inner head arises tendinous from the other side of the middle line, decussating with its fellow; the outer and stronger head arises by a shorter tendon, and is soon joined by the inner head. About an inch (2·5 cm.) above the pubes, a fleshy mass is formed, which expands as it ascends into a broad sheet, which below the umbilicus lies close to its fellow of the opposite side. Above, the two muscles are separated by an interval of at least a quarter of an inch (6 mm.). The insertion, which is by short tendinous fibres, is three or four times the width of the origin. The muscle is also curved considerably forwards to correspond with the convexity of the front wall of the abdomen. At certain intervals, transverse bands of fibrous tissue extend in an irregular zigzag manner across the muscle, especially upon its anterior surface. These are called the **lineæ transversæ**, and the transverse depressions which they produce are usually to be seen and felt through the skin. They are generally three or four in number on either side. One is situated opposite the umbilicus; the second opposite the tip of the ensiform cartilage; the third half way between these points; and a fourth is sometimes present which extends incompletely across the muscle at some distance below the umbilicus. They are firmly connected with the anterior layer of the strong sheath of the muscle, which will afterwards be described. They do not extend through the whole thickness of the muscle, being deficient behind.

Nerve-supply.—From the terminal filaments of the anterior branches of the six lower thoracic nerves which enter the muscle on its posterior surface near the outer border; and from the ilio-hypogastric branch of the lumbar plexus.

Action.—(1) By the tendency of the curved bands of the muscle to become straight during contraction, all the viscera contained in its concavity are compressed. It will, therefore, help in defecation, micturition, and parturition; also in expiration, and especially in strong expiratory efforts, such as coughing and sneezing. (2) By drawing down the ensiform cartilage and the anterior extremities of the middle ribs, it flexes the thorax upon the pelvis, and at the same time acts as a flexor of the thoracic and lumbar portions of the spine. Acting less strongly, it fixes the sternum, so that the sterno-mastoids by their contraction may flex the head, e.g. in rising from the recumbent position. (3) Taking its fixed point from above, it will draw upwards the pubic portion of the pelvis, and so flex the pelvis upon the thorax, as when the lower part of the body is drawn up towards the chest in climbing.

The **lineæ transversæ,** which are the remnants of the septa which divide the muscular structure at intervals in the lower vertebrates, and which in the crocodile form the abdominal ribs, have had various uses assigned to them. In the first place, they will tend to keep the muscular fibres in their proper place, and prevent them from being separated so as to allow of ventral hernia. Secondly, they will enable the muscle to act not only upon the points of bone which form its direct attachment, but, by means of their connection with the sheath of the muscle and the aponeuroses of which it is formed, they will in some measure diffuse the action of the muscle over the lower ribs and the crest of the ilium. Thirdly, they will enable one part of the muscle to act independently, as for example when the lower part exercises some pressure upon the bladder in micturition. Fourthly, they prevent extensive separation when the muscle is injured. On account of the severe strain to which the muscle is exposed, it is sometimes ruptured. If the muscular fibres extended without interruption from the pubes to the ensiform cartilage, such a rupture would occasion a much wider separation, and consequently much greater disablement than is now found to be the case.

Relations.—Superficially, the front layer of its sheath above, and below the pyramidalis; deeply, it is separated from the transversalis fascia and peritoneum in the greater part of its course by the posterior layer of its sheath; in its lower fourth it is in contact with the transversalis fascia; and above, it lies on the cartilages of the fifth to the ninth ribs, and covers the intercostal muscles which lie between them. The deep epigastric artery ascends behind the muscle to join with the superior epigastric branch of the internal mammary.

Variations.—The rectus may be inserted as high as the fourth or even the third rib. A lateral rectus is sometimes found between the external and internal oblique muscles, extending from the tenth rib to the iliac crest.

TRANSVERSE AND OBLIQUE MUSCLES

This group consists of three muscles—the obliquus externus, the obliquus internus, and the transversalis—which lie in successive strata in the abdominal wall.

1. OBLIQUUS EXTERNUS

The **obliquus externus abdominis**—named from its position and direction—is a broad curved sheet, partly muscle and partly aponeurosis, of an irregularly quadrilateral shape.

Origin.—The outer surface of the eight lower ribs about their middle by a series of nearly horizontal lines which, after crossing each rib obliquely downwards and backwards, extend for a short distance along their lower borders.

Insertion.—(1) By a strong aponeurosis along the whole of the linea alba; (2) the front of the os pubis close to the symphysis; (3) the spine of the pubes and the adjacent part of the ilio-pectineal line; (4) the deep fascia of the thigh in a thickened band which stretches from the spine of the pubes to the anterior superior spine of the ilium: (5) the anterior half of the outer lip of the crest of the ilium.

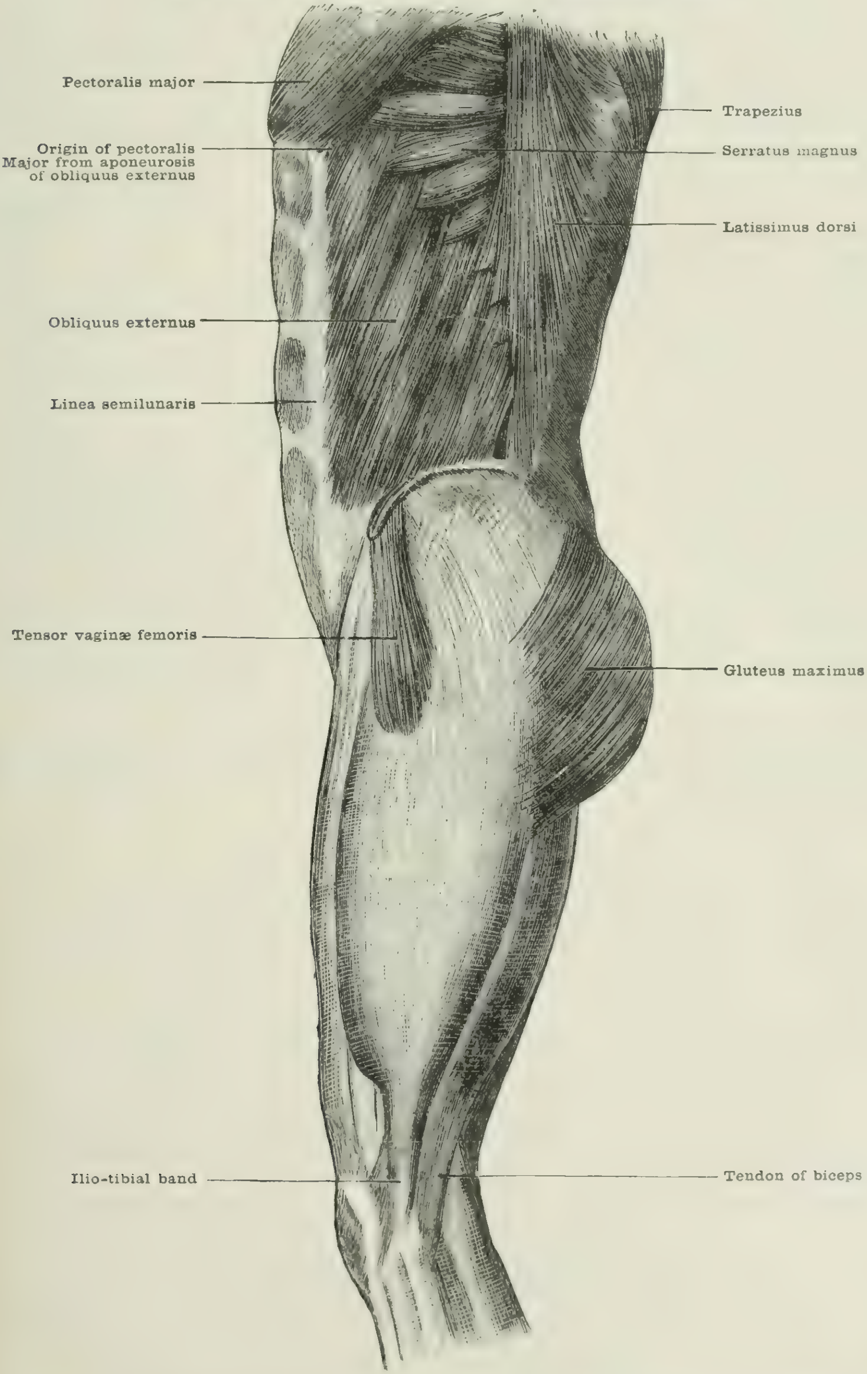
Structure.—At their origin the muscular fibres form a series of teeth which interdigitate in the upper part of the muscle with the serratus magnus, and in the lower with the latissimus dorsi. The general direction of the origin is an oblique line somewhat curved upon itself so as be convex upwards and backwards. Above and below, the origin is nearer to the anterior extremities of the ribs. From this origin the fleshy fibres pass downwards and forwards, and at the same time diverge fanwise, at first lying upon the ribs and their cartilages, and then without any bony support as part of the muscular wall of the abdomen. The change from fleshy to tendinous fibres takes place at some distance from the outer border of the rectus muscle, in such a way that the fleshy mass terminates rather abruptly in a right angle situated in the iliac region of the abdomen. This angle is formed in front by a vertical line, which passes downwards from the tip of the ninth costal cartilage; and below by a horizontal line passing forwards from a point upon the crest of the ilium an inch or two (2·5 to 5 cm.) behind the anterior superior spine. This abrupt limitation of the muscular fibres gives rise to a projection which is distinctly visible through the skin in a muscular subject. The aponeurosis thus formed blends in nearly the whole of its extent with that of the subjacent muscle, the obliquus internus, and in the middle line it unites at the linea alba with that of the opposite side. Above, it extends upwards as high as the insertion of the rectus muscle, of which it forms part of the sheath, and in this locality it gives origin to a part of the pectoralis major.

The insertion into the pubic bone of the same side is interrupted by an interval corresponding to the crest of the pubes, and forms the **external abdominal ring.** From the spine of the pubes to the anterior superior spine of the ilium, the aponeurosis forms a thickened band slightly convex downwards, which blends with the fascia lata, and is called **Poupart's ligament.** The rest of the insertion into the outer lip of the crest of the ilium is by short tendinous fibres.

The insertion of the lower edge of the aponeurosis is also carried backwards and outwards from the spine of the pubes along the inner part of the ilio-pectineal line by a horizontal triangle of fascia called **Gimbernat's ligament.** This ligament is attached to the lower end of Poupart's ligament in front, and it presents a concave surface upwards, upon which lie the structures which emerge through the external abdominal ring. The fibres of Gimbernat's ligament are continued upwards and inwards beyond the ilio-pectineal line to the front of the rectus and the linea alba by a layer called the *triangular fascia*, which lies behind the inguinal canal and the external abdominal ring.

The **external abdominal ring** (fig. 285) is an obliquely directed slit or narrow triangular aperture in the aponeurosis of the obliquus externus, which transmits the spermatic cord in the male, and the round ligament of the uterus in the female. The slit is formed by the divergence of the obliquely directed fibres of the aponeurosis.

FIG. 303.—EXTERNAL OBLIQUE AND ILIO-TIBIAL BAND.


Pectoralis major
Origin of pectoralis Major from aponeurosis of obliquus externus
Obliquus externus
Linea semilunaris
Tensor vaginæ femoris
Ilio-tibial band
Trapezius
Serratus magnus
Latissimus dorsi
Gluteus maximus
Tendon of biceps

Those above, which form the **inner pillar**, as it is called, of the ring, run downwards and inwards to be attached to the front of the symphysis pubis; those below, which form the **external pillar** of the ring, form a thin edge at first, but thicken just before their attachment to the spine of the pubes and the inner extremity of the ilio-pectineal line, for at this point the external pillar is identical with Poupart's ligament. Upon the surface of the obliquus externus, close to the external abdominal ring, the oblique fibres of the aponeurosis are fastened together by some transversely directed fibres, the **intercolumnar** fibres, which run upwards and inwards from Poupart's ligament, limiting and rounding off the upper and outer end of the external abdominal ring. A thin membrane, the **intercolumnar fascia**, is prolonged from the edges of this opening over the spermatic cord and round ligament, of which it forms the external envelope.

Nerve-supply.—From the anterior branches of the lower thoracic nerves, by means of numerous filaments which, passing through the internal oblique, enter the muscle on its deep surface.

Action.—(1) The curved muscular fibres in their contraction tend to become straight and so compress the viscera which lie in their concavity; they act in defecation, micturition, parturition, and all expiratory efforts; (2) the two obliqui externi acting together will draw upwards the front part of the pelvis, and so flex it upon the thorax; (3) the muscle of one side, acting alone or in conjunction with the internal oblique of the opposite side, will rotate the pelvis and the lower part of the body to the same side; (4) it will tend by its posterior fibres to draw the crest of the ilium upwards towards the lower ribs, and will thus act as a lateral flexor of the pelvis upon the thorax; (5) acting from below, the muscles of the two sides will draw the thorax downwards and forwards and flex the lumbar and lower part of the thoracic spine; (6) it will rotate the thorax upon the pelvis so as to turn the thorax and the upper part of the body to the opposite side; (7) the posterior fibres will flex the thorax laterally.

Relations.—Superficially, the integuments, and for a short space behind the latissimus dorsi; deeply, the lower ribs, their cartilages, the intercostal muscles between them, and the internal oblique; and below, the spermatic cord or round ligament in the inguinal canal.

Variations.—The oblique externus may rise from more or fewer ribs. Occasionally a deeper plane is separated from the rest of the muscle. In one case, the anterior part of the aponeurosis was observed to be wanting.

2. OBLIQUUS INTERNUS ABDOMINIS

The **obliquus internus abdominis** (fig. 266)—named from its relation to the preceding muscle and the direction of its fibres—is an irregular quadrilateral curved sheet, partly fleshy and partly aponeurotic.

Origin.—(1) The outer half of Poupart's ligament; (2) the anterior two-thirds of the space intervening between the inner and outer lips of the crest of the ilium; (3) the outer and posterior aspect of the aponeurosis of the transversalis abdominis (which aponeurosis is also called the **lumbar fascia**).

Insertion.—(1) For about one inch (2·5 cm.) into the inner extremity of the ilio-pectineal line; (2) the anterior border of the crest of the pubes; (3) the whole length of the linea alba; (4) the lower borders of the cartilages of the last three ribs.

Structure.—Arising by fleshy and short tendinous fibres intermingled, a fleshy sheet is soon formed, the fibres of which diverge; the anterior passing forwards and downwards, the middle forwards and upwards, and the posterior directly upwards to their insertion, which is by means of a broad aponeurosis. At the front of the lower intercostal spaces the fibres run parallel to, and in the same plane with, the internal intercostals. The position of the change from fleshy to aponeurotic fibres may be indicated by two lines at right angles to each other; one passing upwards and a little outwards from the middle of Poupart's ligament, the other horizontally forwards below the tip of the last rib, and near the edges of the lower rib cartilages. The aponeurosis is blended with that of the external oblique, and in its upper three-fourths it divides into an anterior and a posterior plane which together form the sheath of the rectus muscle. In the lower fourth of the abdomen the whole of the aponeurosis passes in front of this muscle. The line of division of the aponeurosis of the internal oblique is indicated on the surface of the abdomen by a furrow called the **linea semilunaris,** which lies between the fleshy part of the muscle and the outer border of the rectus muscle, and forms a curve, concave inwards, which extends from the cartilage of the ninth rib above to the vicinity of the pubes below.

The **plica semilunaris,** or fold of Douglas, on the other hand, is the name given to the lower edge of the posterior sheath of the rectus, when that muscle pierces the aponeuroses so as to lie behind all of them in the lower fourth of its course. The lowest portion of the aponeurosis of insertion of the obliquus internus is closely blended with that of the transversalis abdominis, and is called the **conjoined tendon.**

Nerve-supply.—From the anterior primary branches of the lower thoracic nerves, and from the first nerve of the lumbar plexus by means of the ilio-inguinal and ilio-hypogastric nerves. The main branches of these nerves run forwards between this muscle and the transversalis abdominis, and give off their filaments to the internal surface of the muscle; some also are distributed to the muscle by the branches which perforate it in order to supply the external oblique.

Action.—(1) The fibres of the muscle being curved tend to flatten upon their contraction and so to compress the viscera contained within their concavity; they will therefore help in defecation, micturition, parturition, and all expiratory efforts. (2) It will also assist expiration by drawing the lower ribs downwards. (3) When both muscles act together, they flex the thorax upon the pelvis. They will also flex the lumbar and lower thoracic spine. (4) When the muscle of one side acts alone, or in conjunction with the obliquus externus of the other side, it will rotate the thorax to its own side. (5) The posterior fibres of the muscle will draw down the side of the thorax; it will therefore be a lateral flexor of the thorax and of the lumbar and lower dorsal spine. (6) Acting from the thorax, this muscle will flex the pelvis, rotate it to the opposite side, and by means of its posterior fibres it will act as a lateral flexor of the pelvis.

Relations.—Superficially, the external oblique and latissimus dorsi; deeply, the transversalis abdominis. Its lower margin lies for a short distance in front of the inguinal canal, containing the spermatic cord in the male, and the round ligament in the female. The conjoined tendon lies internally beneath these structures. The aponeurosis of the internal oblique is also in relation with the rectus muscle, of which it forms the sheath in the upper three-fourths of its extent.

Variations.—Sometimes the muscle is crossed close to its insertion into the ribs by tendinous intersections, which probably represent ribs.

CREMASTER

The **cremaster** (fig. 285)—named from its action as a suspender of the testicle (*κρεμαστήρ* a suspender, from *κρεμάννυμι* to hang)—is really a detached part of the obliquus internus, forming with the fascia which connects its fibres a thin loop-shaped band, which in the male envelopes the lower part and front of the testicle and spermatic cord. In the female it is either entirely absent, or a few fibres upon the front of the round ligament take its place.

Origin.—The upper and deep surface of Poupart's ligament about its middle point.

Insertion.—(1) The spine, and crest of the pubic bone; (2) the front of the **fascia propria** or **infundibuliform fascia,** which envelopes the testicle and spermatic cord.

Structure.—The fibres, which differ from all other muscles in their scattered and separate character, spring fleshy from the concavity of Poupart's ligament on the deep aspect of the aponeurosis of the obliquus externus, in continuation of the origin of the obliquus internus. Three main divisions may be noted:—(1) A series of loops which pass from this origin at different heights in front of the cord and testicle, with their convexities directed downwards and closely connected with the fascia propria of the testicle; finally, they collect into a narrow tendinous band, which is attached to the spine and crest of the pubes. (2) A group of divergent fleshy fibres, which pass from the origin downwards and inwards to be lost upon the fascia propria. (3) A smaller group, which descend from the tendinous insertion to be lost in a similar manner upon the front of the fascia propria.

Between these fleshy fibres, which are often thin and difficult to recognise, there is a layer of connective tissue, called the cremasteric fascia, which unites them and forms one of the coverings of the testicle and cord.

Nerve-supply.—The genital branch of the genito-crural, from the first and second lumbar nerves, gives off numerous filaments which enter the muscle upon its deep and posterior aspect.

Action.—To raise the testicle, and draw it upwards towards the external abdominal ring. This action is involuntary, and is usually of a reflex character, being readily excited by any irritation of the adjacent skin either of the scrotum or thigh.

Relations.—Superficially, the external oblique aponeurosis above, the intercolumnar fascia, dartos, and integuments below; deeply, the spermatic cord and testicle with its fascia propria.

3. TRANSVERSALIS ABDOMINIS

The **transversalis abdominis**—named from the general direction of its fibres—is an irregularly quadrilateral curved sheet, partly muscular, partly aponeurotic.

Origin.—(1) The inner surface of the cartilages of the last six ribs, close to their junction with the ribs, by teeth which interdigitate with the attachments of the diaphragm; (2) the strong aponeurosis called the **lumbar fascia,** which arises (*a*) by its anterior layer from the front of the transverse processes of the five lumbar vertebræ, (*b*) by its middle layer from the tips of the transverse processes of the five lumbar vertebræ, (*c*) by its posterior layer from the general **vertebral aponeurosis** which is attached to the spines of the thoracic, lumbar, and sacral vertebræ; (3) the anterior two-thirds of the inner lip of the crest of the ilium; (4) the outer third of Poupart's ligament.

Insertion.—(1) The whole length of the linea alba; (2) the anterior border of the crest of the pubes; (3) the inner end of the ilio-pectineal line for about one inch and a half (4 cm.).

Structure.—Arising by short tendinous intermixed with fleshy fibres, the muscle passes transversely forwards, diverging slightly to its insertion. The change from fleshy to aponeurotic fibres is in a curved line, the upper and lower extremities of which approach the linea alba more closely than in the central part of the muscle. In the upper part the fleshy fibres are overlapped in front by the rectus muscle; and at the lower border of the muscle where it terminates in a small arch, passing over the spermatic cord or round ligament, the fleshy fibres cease just above the middle of Poupart's ligament. The muscles of the two sides, joined as they are by the central aponeurosis, may be looked upon as a single muscle with a central aponeurosis, like the diaphragm.

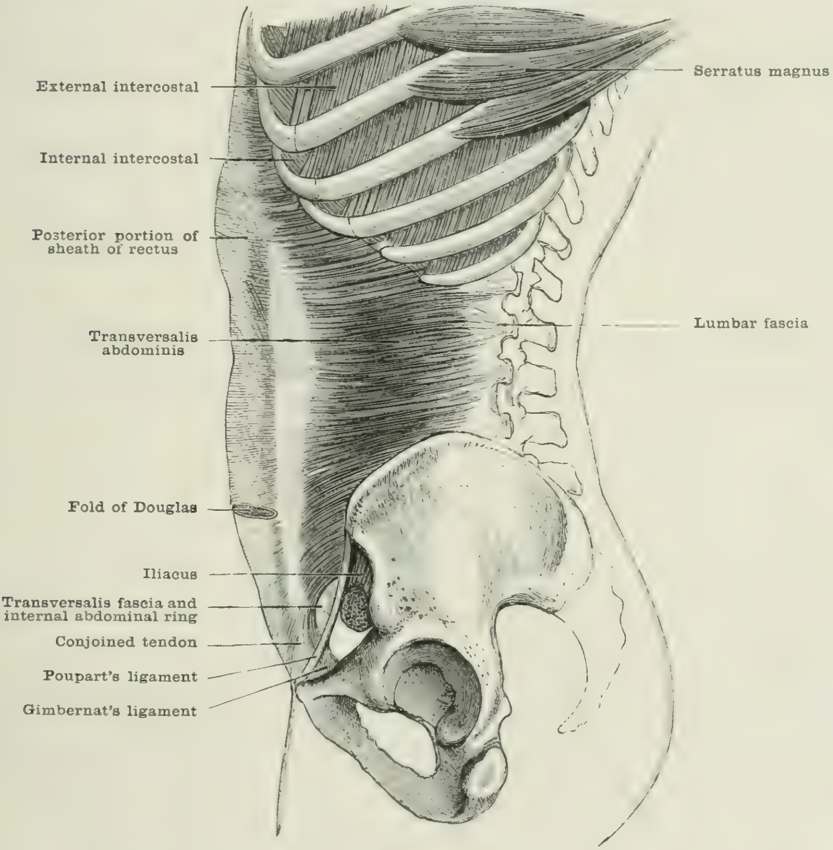
In its upper three-fourths the **anterior aponeurosis** is closely blended with the posterior division of the aponeurosis of the internal oblique muscle, and forms the hinder part of the sheath of the rectus in this region. In the lower fourth, the anterior aponeurosis is blended with the undivided aponeurosis of the internal oblique, and passes in front of the rectus muscle and the pyramidalis.

The **posterior aponeurosis,** or **lumbar fascia,** consists of strong transverse fibres. The middle layer is the strongest, and has in its substance fibrous bands passing outwards from the tips of the transverse processes of the lumbar vertebræ, and continuing the series of the ribs connected with the dorsal transverse processes. Between this middle layer and the anterior layer which springs from the front of the tips of the transverse processes is placed the quadratus lumborum; and a thickening of this anterior layer passing from the tips of the transverse processes of the first and second lumbar vertebræ to the lowest rib, called the *ligamentum* *arcuatum externum*, gives origin to a part of the diaphragm. Between the middle and posterior layers is placed the erector spinæ muscle. This posterior layer blends with the vertebral aponeurosis, and gives origin to the latissimus dorsi, the serratus posticus inferior, and other muscles.

Nerve-supply.—The anterior primary branches of the lower thoracic nerves and the ilio-hypogastric and ilio-inguinal branches of the first nerve of the lumbar plexus. The nerves as they run forward between this muscle and the obliquus internus distribute filaments to its outer surface.

Action.—The muscles of the two sides with their intervening aponeurosis form a strong girth round the abdominal viscera, and by their contraction compress most powerfully the contents of the abdomen.

FIG. 304.—TRANSVERSALIS ABDOMINIS AND SHEATH OF RECTUS.


External intercostal
Internal intercostal
Posterior portion of sheath of rectus
Transversalis abdominis
Fold of Douglas
Iliacus
Transversalis fascia and internal abdominal ring
Conjoined tendon
Poupart's ligament
Gimbernat's ligament
Serratus magnus
Lumbar fascia

It will thus be seen that the three layers of the transverse muscle in the abdominal wall cross one another at various angles, one pair passing transversely forwards, a second forwards and upwards, and a third forwards and downwards. The following objects are gained by this arrangement: (1) the wall is rendered much stronger, and the probability of a hernial protrusion of any portion of the viscera between the separated fibres of the muscles is diminished; (2) contraction of the wall is permitted in every direction; (3) greater approximation of the movable boundaries of the abdominal wall is obtained by means of the obliquity of the muscles which effect this movement. For example, two parallel bones can have the distance between them diminished only by one half, supposing that the muscular fibres producing this movement run perpendicularly from one bone to the other; but if the fibres cross one another obliquely, like those of the external and internal oblique muscles, in passing from the crest of the ilium to the lower ribs, a much more complete approximation of the bones is effected.

Relations.—Superficially, the obliquus internus, the cartilages of the lower ribs, some small vessels, and the lower intercostal nerves; above, it is continuous with the lower border of the triangularis sterni; below, it lies above the spermatic cord or round ligament, and its conjoined tendon lies for a short distance beneath these structures; deeply, the transversalis fascia which separates it from the peritoneum.

The **sheath of the rectus** is formed by the aponeuroses of the three preceding muscles. That of the obliquus internus divides into an anterior and posterior layer. The anterior layer blended with the aponeurosis of the obliquus externus forms the **front portion of the sheath.** Above, it is attached to the cartilages of the fifth, sixth, and seventh ribs; and internally it blends with the posterior portion of the sheath along the linea alba. The **posterior portion of the sheath** is formed by the posterior layer of the aponeurosis of the obliquus internus, which is blended with the aponeurosis of the transversalis. Above, it is attached to the lower edge of the cartilages of the seventh and eighth ribs, and to the ensiform cartilage. Internally it blends with the front portion of the sheath along the linea alba. Rather nearer the umbilicus than the pubes, the posterior portion of the sheath becomes suddenly much thinner and weaker at the **fold of Douglas,** which is a transverse line indicating that the fibres of the abdominal aponeuroses which have down to this level formed the posterior portion of the sheath, now pass to its front wall. Below this level the posterior portion of the sheath is formed by a thickening of the **transversalis fascia** (page 411).

POSTERIOR VERTICAL MUSCLE—QUADRATUS LUMBORUM

The **quadratus lumborum** (fig. 286)—named from its approximately square shape and its position in the region of the loins—is a thick quadrilateral sheet.

Origin.—(1) About two inches (5 cm.) of the inner lip of the crest of the ilium at the junction of its middle and posterior thirds; (2) the ilio-lumbar ligament; (3) the tips of the transverse processes of the three or four lower lumbar vertebræ.

Insertion.—(1) The inner half of the lower border of the last rib; (2) the tips of the transverse processes of the upper three or four lumbar vertebræ; and (3) the fibrous continuations which pass out from these transverse processes in the substance of the middle portion of the lumbar fascia, and which represent the abdominal ribs.

Structure.—This muscle varies considerably in its structure and arrangement, the origins from, and insertions into the transverse processes differing much in different subjects. Its origin is usually by short tendinous intermixed with fleshy fibres, and extends at its lower part all along the ilio-lumbar ligament, and behind the attachment of this ligament from the inner lip of the crest of the ilium. The fibres converge somewhat as they ascend; the outermost, passing upwards and inwards to the middle point of the lower border of the last rib, while the inner fibres pass vertically upwards along the tips of the transverse processes of the lumbar vertebræ, from which they receive short tendons, and they sometimes give tendinous slips to these processes. On the anterior and posterior surfaces of the muscle are often seen ascending fibres from the transverse processes, which diverge slightly before they are inserted into the lower border of the last rib.

Nerve-supply.—From the twelfth thoracic and upper lumbar nerves, by filaments which enter the muscle upon its anterior surface near its inner border.

Action.—(1) It will draw downwards the last rib, and will therefore act as a lateral flexor of the thorax as well as of the lower thoracic and the lumbar spine; (2) it will assist in expiration by drawing down the last rib; (3) taking its fixed point from the last rib, it will draw upwards the crest of the ilium, and so act as a lateral flexor of the pelvis upon the thorax.

Relations.—In front lie the kidney, the colon, the psoas, the lumbar arteries and nerves, separated from it by the anterior layer of the lumbar fascia. Behind, the middle layer of the lumbar fascia separates it from the erector spinæ, and along its inner border are placed the intertransversales.

The **transversalis fascia**, which lines the interior of the muscular portion of the abdominal parietes, is a thin layer of connective tissue. It is best marked in the lower part of the front of the abdomen, where some of the muscular and aponeurotic layers are deficient. Below, it is attached to the inner border of the whole length of the crest of the ilium, and to the outer half of Poupart's ligament, where it blends with the iliac fascia covering the iliacus muscle. Beneath the inner half of Poupart's ligament it is somewhat thickened, and called the **deep crural arch.** This is but loosely attached to Poupart's ligament, and the fascia is continued into the thigh, where it forms the front of the sheath of the femoral vessels. Internally to this, it is attached to the free margin of Gimbernat's ligament, and the inner end of the ilio-pectineal line. Further inwards it is inserted along the posterior border of the crest of the pubes. At the back of the linea alba it is continuous with the fascia of the opposite side. Behind the lower part of the rectus muscle it is thickened, and takes the place of the posterior portion of the sheath from the pubes to the fold of Douglas. Above, it becomes thin and blends with the fascia covering the under surface of the diaphragm; and behind, it is lost in the loose fat which covers the posterior surface of the kidneys, together with the back of the ascending and descending colon.

About half an inch (1·2 cm.) above Poupart's ligament, half way between the anterior superior spine and the symphysis pubis, it is perforated by the spermatic cord in the male, and the round ligament in the female. To the margins of the opening, which is called the **internal abdominal ring,** is attached a tubular prolongation, the **infundibuliform fascia,** which invests the cord or round ligament. The connection of this tube to the rest of the fascia may be compared to the attachment of the sleeve to a coat. No opening is therefore visible from the exterior until the sleeve-like tube has been divided.

MUSCLES OF THE BACK

The first and second layers have already been described, as they belong to the groups of muscles which pass from the thorax to the bones of the upper extremity. The third layer consists of muscles which stretch in a nearly transverse direction from the spinous processes of the vertebræ to the back of the ribs, viz. the serratus posticus superior and the serratus posticus inferior.

THIRD LAYER

1. SERRATUS POSTICUS SUPERIOR

The **serratus posticus superior**—named from its saw-like edge and its relation to the other serrati—is a quadrilateral sheet with a toothed outer margin.

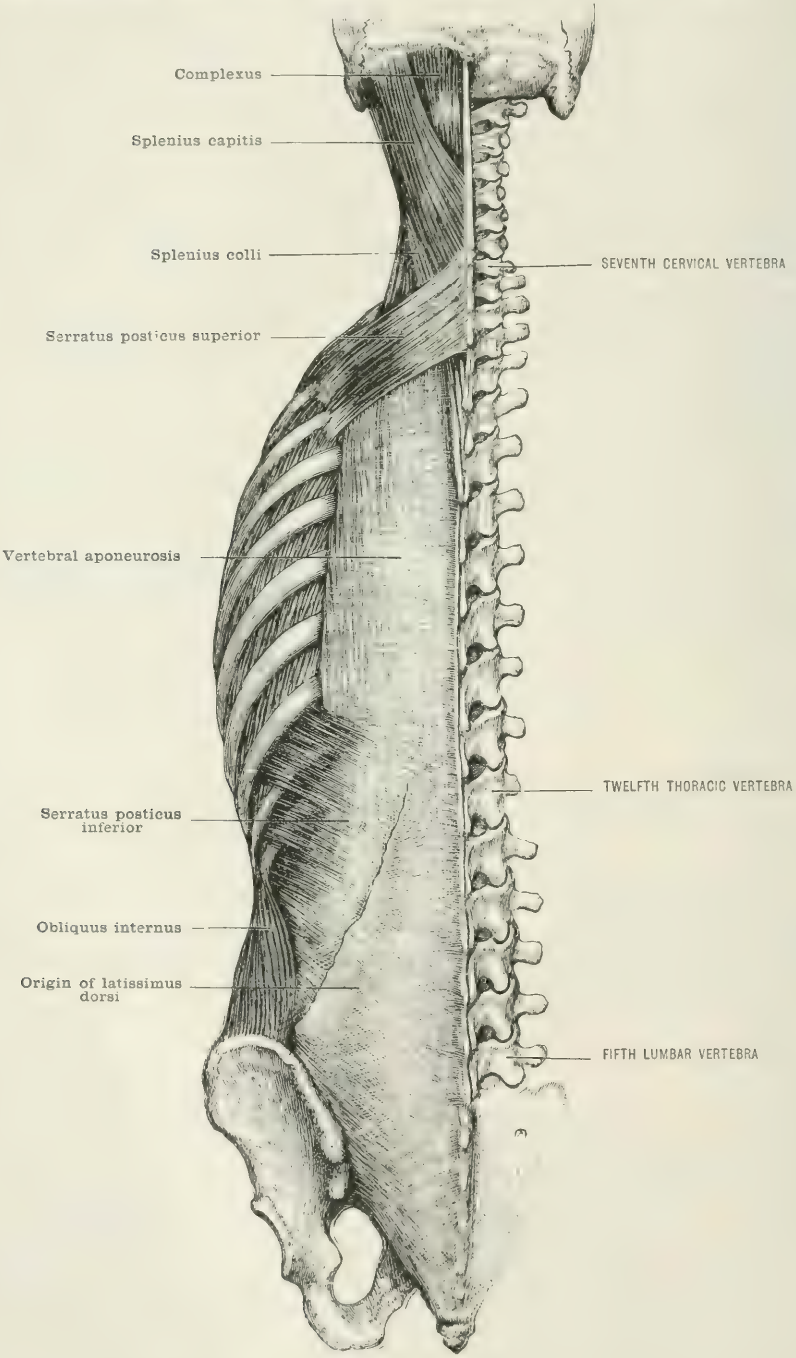
Origin.—(1) The outer surface of the lower part of the ligamentum nuchæ near its posterior edge; (2) the spines of the last cervical and first two thoracic vertebræ, and the supraspinous ligament connecting them.

Insertion.—The upper borders and outer surfaces of the second to the fifth ribs, external to their angles.

Structure.—The inner half is a tendinous sheet, the fibres of which run downwards and outwards, and when they have passed beyond the line of the transverse processes they become fleshy and are inserted into the ribs by the lower borders of the four teeth into which the muscle divides.

Nerve-supply.—From the second and third intercostals by fine filaments which enter the outer part of its deep surface.

FIG. 305.—THE THIRD AND FOURTH LAYERS OF THE MUSCLES OF THE BACK.


Complexus
Splenius capitis
Splenius colli
Serratus posticus superior
Vertebral aponeurosis
Serratus posticus inferior
Obliquus internus
Origin of latissimus dorsi
SEVENTH CERVICAL VERTEBRA
TWELFTH THORACIC VERTEBRA
FIFTH LUMBAR VERTEBRA

Action.—To raise the ribs into which it is inserted; and therefore to assist in inspiration.

Relations.—Superficially, the trapezius, levator anguli scapulæ, rhomboideus minor and major; deeply, the vertebral aponeurosis which separates it from the splenius and the more superficial spinal muscles; farther outwards the muscle covers part of the external intercostals.

Variations.—The slips vary in number. Sometimes it gives off a slip from its upper border or posterior surface which goes to the levator anguli scapulæ, the mastoid process, or the superior nuchal line.

2. SERRATUS POSTICUS INFERIOR

The **serratus posticus inferior**—named also from its outer saw-like margin, and its position—is a quadrilateral sheet.

Origin.—The spines of the two lower thoracic and two upper lumbar vertebræ.

Insertion.—The lower borders of the last four or five ribs external to their angles, except in the case of the last rib which has no angle; and as far forwards as the costal origins of the latissimus dorsi.

Structure.—More than half of the muscle is aponeurosis, which is blended with that of the latissimus dorsi on its superficial, and of the erector spinæ on its deep aspect, and forms a part of the vertebral aponeurosis, which blends with the posterior layer of the lumbar fascia. The fleshy fibres are directed upwards and outwards from this aponeurosis, arising in an oblique line which is nearer the spine above than below, and inserted directly, or with small tendinous attachments into the ribs. Each succeeding tooth slightly overlaps, and extends farther forwards than the one below. The middle teeth are the largest.

Nerve-supply.—Filaments from the tenth and eleventh intercostals which enter the deep surface of the outer part of the muscle.

Action.—(1) To depress the lower ribs; (2) to fix them, so as to enable the diaphragm to contract. It is therefore in this respect a muscle of inspiration.

Relations.—Superficially, the latissimus dorsi; deeply, the erector spinæ with its upward continuations, also the levatores costarum, and the external intercostal muscles.

GENERAL ARRANGEMENT OF THE MUSCLES ACTING UPON THE SPINAL COLUMN

THE VERTEBRAL APONEUROSIS

Beneath the serrati postici are arranged what may be called the muscles of the back proper, viz. those which move the vertebral column and act chiefly upon the spines and transverse processes of the vertebræ and the parts of the skull which are serially continuous with them. They lie for the most part in the groove on either side of the spines of the vertebræ, and they are bound down and protected by the strong **vertebral aponeurosis** which is blended below with the tendinous origin of the latissimus dorsi, the serratus posticus inferior, and the erector spinæ. Laterally, it is attached to the angles of the ribs; and internally, to the spines of the vertebræ and the supra-spinous ligament. Above, it passes beneath the tendon of the serratus posticus superior, and is then lost in the thin fascia covering the splenii.

The back muscles proper may be arranged according to their direction into two great divisions, each of which contains two classes. The **vertical** division consists of muscles which run between similar points of bone, and its two classes will contain the *spinales*, which connect the spines of the vertebræ with one another and with the mesial portion of the occipital bone; the *transversales*, which connect the transverse processes of the sacral and lumbar regions with the transverse processes and the adjacent portions of the ribs in the thoracic region, the articular and transverse processes in the cervical region, and the mastoid process at the upper end of the spinal column. The **oblique** division consists of muscles which run obliquely, and contains two classes: the *spino-transversales*, which run upwards and outwards from spine to transverse process, or to a point of bone which corresponds to a transverse process, e.g. the mastoid process; and the *transverso-spinales*, which run upwards and inwards from transverse process to spine.

The action of these muscles will be easily ascertained by observing to which class they belong. The *spinales* will simply extend, while the *transversales* will produce lateral flexion as well as extension. The oblique, in addition to extension and lateral flexion, will also produce rotation wherever the ligaments and processes of the vertebræ permit of this movement.

FOURTH LAYER

The fourth layer of the muscles of the back consists of two muscles, which are closely connected with each other, and belong to the *spino-transversalis* class of the *oblique* division.

1 AND 2. SPLENIUS

The **splenius** (fig. 305)—named from σπλήνιον a bandage or compress, probably on account of the way in which it crosses over and binds down the complexus and other muscles—is a broad four-sided sheet, divided into two parts at its insertion: the one part being the **splenius capitis,** and the other the **splenius colli.**

(1) SPLENIUS CAPITIS

Origin.—(1) The lower two-thirds of the ligamentum nuchæ; (2) the spines of the seventh cervical and upper two thoracic vertebræ, and the interspinous ligaments between them.

Insertion.—The outer third of the middle nuchal line of the occipital bone, and the back part of the outer surface of the mastoid process of the temporal bone.

Structure.—Arising by a short tendinous aponeurosis, the fleshy fibres pass upwards and outwards parallel to each other, and are inserted by short tendinous fibres, except along the anterior border, where the tendon of insertion extends more than an inch (2·5 cm.) downwards.

Nerve-supply.—The external branches of the posterior primary divisions of the middle cervical nerves which enter the outer part of the deep surface of the muscle.

Action.—(1) To extend the head and neck; (2) to flex them laterally; (3) to rotate the face to the same side.

(2) SPLENIUS COLLI

Origin.—The spines of the third to the sixth thoracic vertebræ, and the interspinous ligaments between them.

Insertion.—The back of the posterior tubercles of the transverse processes of three or four upper cervical vertebræ.

Structure.—Of parallel fleshy fibres with a short aponeurotic origin, and inserted by small tendons, the highest of which is the largest.

Nerve-supply.—The external branches of the posterior divisions of the lower cervical nerves.

Action.—(1) To extend the upper part of the neck; (2) to flex it laterally; (3) to rotate it to the same side.

Relations of the splenius.—Superficially, the sterno-mastoid, trapezius, serratus posticus superior, and the levator anguli scapulæ which conceals the splenius colli in the posterior triangle of the neck. Beneath lie the complexus, trachelo-mastoid, cervicalis ascendens, and transversalis colli.

Variations.—The number of the thoracic vertebræ from which the splenii arise varies. The splenius colli may be absent. The slip mentioned in the variations of the serratus posticus superior may be considered to be a variation of the splenii.

FIFTH LAYER

The fifth layer consists of **vertical** muscles, and contains both spinales and transversales. To the latter class belong the greater part of the erector spinæ and the seven muscles which either spring from it or are serially continuous with it: viz. the ilio-costalis, accessorius ad ilio-costalem, cervicalis ascendens longissimus dorsi, transversalis colli, trachelo-mastoid, and the spinalis dorsi.

1. ERECTOR SPINÆ

The **erector spinæ**—named from its function—is a broad and very strong membranous sheet of a triangular shape, with a layer of fleshy fibres upon its deep surface, and it divides in the lumbar region into three longitudinal series of muscles which fill the greater part of the vertebral groove.

Origin.—(1) The spines of the two last thoracic, all the lumbar, and the four upper sacral vertebræ; (2) the back of the side portion of the fourth sacral vertebra; (3) the posterior sacro-iliac ligament, a few of these fibres being continuous with the origin of the gluteus maximus; (4) the upper part of the posterior superior spine of the ilium, and the posterior fifth of the iliac crest.

Insertion.—It is continuous with the spinalis dorsi, longissimus dorsi, and ilio-costalis.

Structure.—A strong membranous sheet, everywhere continuous except at the origin from the lower thoracic and upper lumbar spines, where it is partly divided into separate tendons.

It breaks up into fleshy fibres in a line which stretches obliquely upwards and inwards from the front of the iliac origin to the last thoracic spines. Fleshy fibres also arise upon its deeper surface at a lower level, and some arise directly from the posterior superior iliac spine and the crest under cover of the tendinous origin.

Nerve-supply.—The external branches of the posterior divisions of the lumbar nerves which enter its deep surface.

Action.—Generally, that of extension of the lumbar spine on the pelvis; but a full account will be given with the description of the succeeding muscles.

Relations.—Superficially, the vertebral aponeurosis, with which it is blended at its origin and for the first two inches (5 cm.) of its course. By this aponeurosis it therefore enters into a close relation with the lower part of the tendons of the latissimus dorsi and serratus posticus inferior. Deeply, the multifidus spinæ, some of the fibres of which arise from it.

The **outer division** extends upwards along the angles of the ribs and the transverse processes of the lower cervical vertebræ, and consists of the ilio-costalis, accessorius ad ilio-costalem, and the cervicalis ascendens. It is separated from the middle division by the external branches of the posterior divisions of the spinal nerves.

OUTER DIVISION

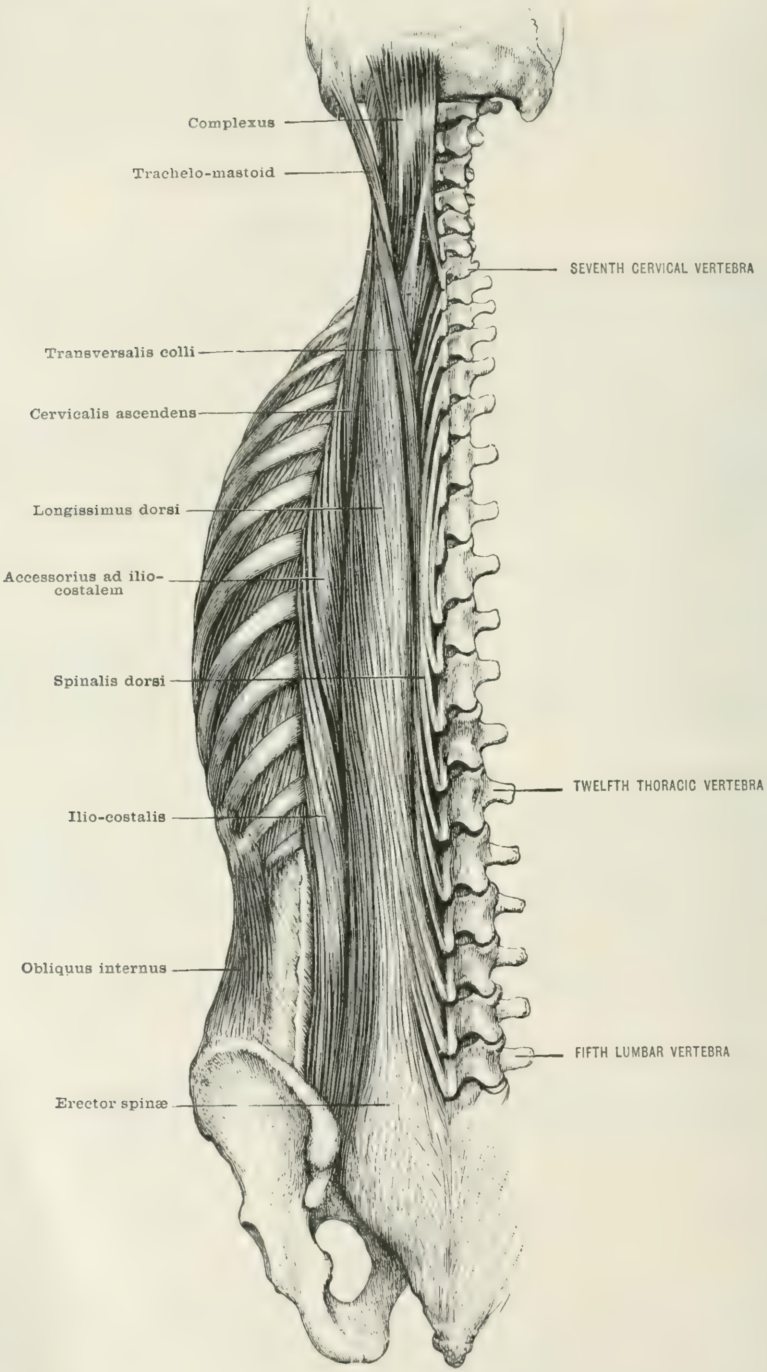
2. ILIO-COSTALIS

The **ilio-costalis,** or **sacro-lumbalis**—named from its attachment to the ilium and ribs—is an elongated muscular sheet, with a serrated outer border formed by the insertion of its tendons into the lower ribs.

Origin.—The outer portion of the erector spinæ.

Insertion.—(1) The angles of all the ribs from the sixth to the eleventh; (2) the lower border of the last rib; (3) the tips of the transverse processes of the lumbar vertebræ, and the fibrous processes which extend outwards from the tips of the transverse processes of the upper lumbar vertebræ into the lumbar fascia.

FIG. 306.—THE FIFTH LAYER OF THE MUSCLES OF THE BACK.


Complexus
Trachelo-mastoid
SEVENTH CERVICAL VERTEBRA
Transversalis colli
Cervicalis ascendens
Longissimus dorsi
Accessorius ad ilio-costalem
Spinalis dorsi
TWELFTH THORACIC VERTEBRA
Ilio-costalis
Obliquus internus
FIFTH LUMBAR VERTEBRA
Erector spinæ

3. ACCESSORIUS AD ILIO-COSTALEM

The **accessorius ad ilio-costalem** or **ad sacro-lumbalem**—named from its being an accessory or addition to the ilio-costalis—is a narrow musculo-tendinous band with a serrated margin on either side.

Origin.—The upper borders of the angles of the seventh to the eleventh ribs and the back of the last rib.

Insertion.—The back of the transverse process of the seventh cervical vertebra, the first rib just external to its tubercle, and the angles of the second to the fifth ribs.

4. CERVICALIS ASCENDENS

The **cervicalis ascendens**—named from its position in the neck and its direction—is a still thinner musculo-tendinous band with serrated margins.

Origin.—The back of the four or five upper ribs just internal to the insertion of the preceding muscle.

Insertion.—The back of the transverse processes of the fourth, fifth, and sixth cervical vertebræ.

Structure.—These three sections form a compound muscle, composed for the most part of fusiform bellies with tendinous origins and insertions, placed in series so that the origins of the higher slips are on a level with the insertions of those that arise six or seven vertebræ or ribs lower down. The lowest of the series arise directly from the muscular mass of the erector spinæ; and the insertions of these lower slips, especially those into the lumbar fascia and last rib, are fleshy. A part of the tendinous origin of the slips of muscle is so closely blended that a complete separation of the muscle into its component parts is impossible. There is a gradual diminution of the size of each component muscle and its tendons as we trace the compound mass upwards.

Nerve-supply.—The external branches of the posterior divisions of the spinal nerves from the lower cervical nerves to the last thoracic.

Action.—(1) To extend the vertebral column, in the lower cervical, thoracic, and upper lumbar regions; (2) to flex it laterally in these regions; (3) to depress the ribs, and so help in expiration.

Relations.—Superficially, the trapezius, rhomboidei, latissimus dorsi, the serratus posticus superior and inferior, and the two splenii; deeply, the intercostal muscles and the levatores costarum; internally, the muscles of the middle division, and the external divisions of the posterior spinal nerves.

Middle Division

The middle division extends along the back of the transverse processes of the lumbar and thoracic vertebræ, the articular processes, and adjacent part of the transverse processes of the cervical vertebræ, and ends at the mastoid process of the temporal bone. It consists of the longissimus dorsi, transversalis colli, and trachelo-mastoid.

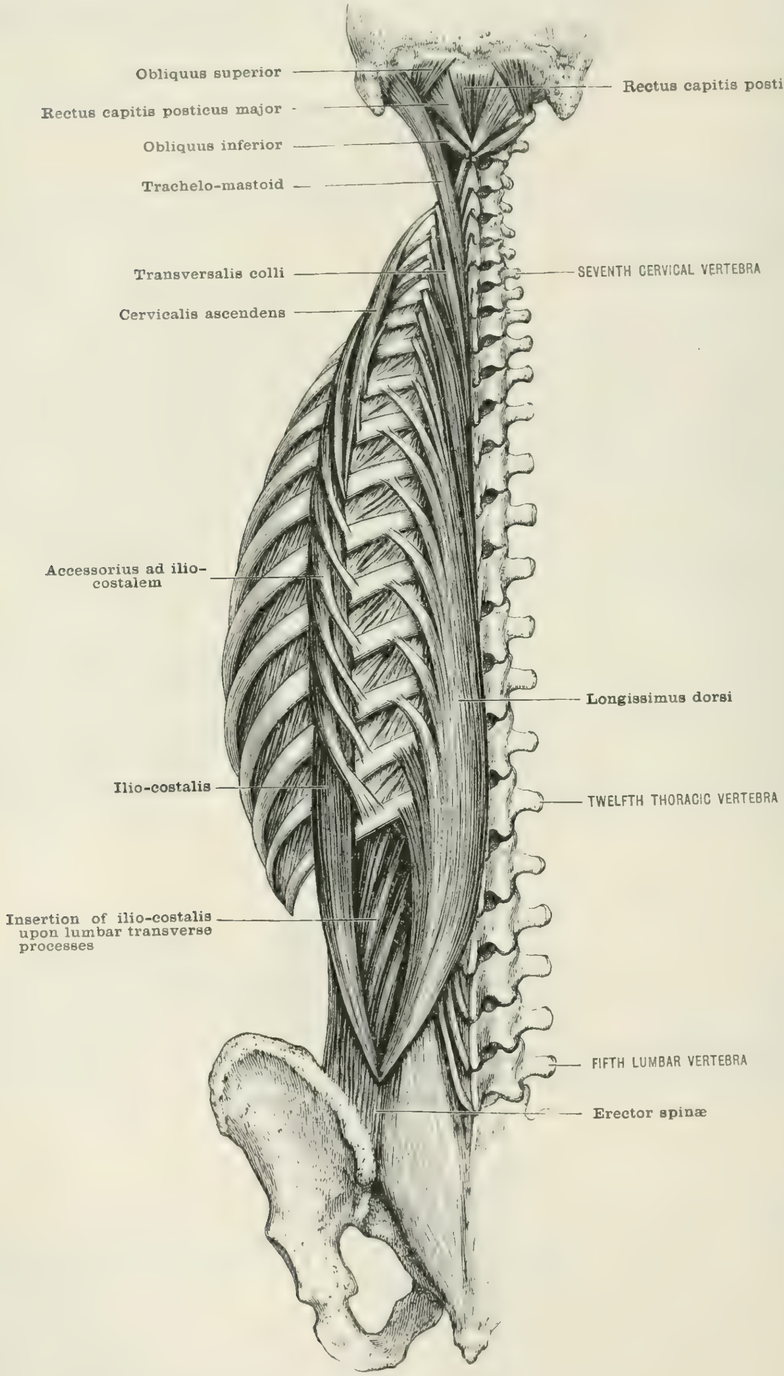
5. LONGISSIMUS DORSI

The **longissimus dorsi**—named from its great length and its position in the dorsal region—is a compound muscle forming a long band, with its surfaces directed outwards and inwards, and an anterior margin provided with an outer and inner row of teeth by which it is inserted.

Origin.—(1) The middle part of the erector spinæ; and (2) the transverse processes of some of the lower thoracic vertebræ.

Insertion.—Externally: (1) the lower border of the back of the transverse processes of the upper lumbar vertebræ; (2) the lower border of the ribs just external to their tubercles. **Internally**: (1) The accessory tubercles of the upper lumbar and lower thoracic vertebræ; and (2) the back of the transverse processes of the rest of the thoracic vertebræ.

FIG. 307.—THE FIFTH LAYER OF THE MUSCLES OF THE BACK, AFTER SEPARATING THE OUTER AND MIDDLE DIVISIONS.


Obliquus superior
Rectus capitis posticus minor
Rectus capitis posticus major
Obliquus inferior
Trachelo-mastoid
Transversalis colli
SEVENTH CERVICAL VERTEBRA
Cervicalis ascendens
Accessorius ad ilio-costalem
Longissimus dorsi
Ilio-costalis
TWELFTH THORACIC VERTEBRA
Insertion of ilio-costalis upon lumbar transverse processes
FIFTH LUMBAR VERTEBRA
Erector spinæ

6. TRANSVERSALIS COLLI

The **transversalis colli**—named from its attachment to the transverse processes and its insertion in the neck—is a similar but narrower musculo-tendinous band.

Origin.—The back of the transverse processes of the five or six upper thoracic vertebræ, internal to the insertion of the preceding muscle.

Insertion.—The posterior tubercles of the transverse processes of the second to the sixth cervical vertebræ.

7. TRACHELO-MASTOID

The **trachelo-mastoid**—named from its origin, part of which is in the neck (*τράχηλος*), and its insertion upon the mastoid process—is a similar but smaller musculo-tendinous band.

Origin.—(1) The back of the articular processes of the lower three or four cervical vertebræ; (2) the back of the transverse processes of the four or five upper thoracic vertebræ.

Insertion.—The posterior border of the mastoid process.

Structure of the middle division.—The three parts of this division have a close connection with one another, and a long tendinous expansion which covers the inner and back part of the longissimus dorsi, is common to it and the spinalis dorsi.

The association of the two upper portions of the division is so close that they are sometimes described together under the name transversalis, the trachelo-mastoid being called the *transversalis capitis* to distinguish it from that part of the muscle which is inserted into the neck. All the upper elements of this long compound muscle have tendinous origins and insertions.

The trachelo-mastoid portion is often found to have a tendinous intersection crossing its fleshy fibres.

Nerve-supply.—The external division of the posterior branches of the lower cervical, all the thoracic, and the upper lumbar nerves.

Action.—(1) To extend the cervical, thoracic, and lumbar spine; (2) to flex it laterally; (3) to extend and laterally flex the head, rotating the face to the same side.

Relations.—Superficially, it is covered by the latissimus dorsi, trapezius, rhomboidei, serratus posticus inferior and superior, and the two splenii; upon its inner border lie the spinalis dorsi and complexus. Upon its outer lie the muscles of the outer division and the external divisions of the posterior branches of the spinal nerves. Beneath lie the multifidus spinæ and the semispinales dorsi et colli.

Inner Division

The **inner division** consists usually of a single muscle, the spinalis dorsi; but sometimes a small muscle, the spinalis colli, continues the series into the neck.

8. SPINALIS DORSI

The **spinalis dorsi**—named from its attachment to the spines in the dorsal region—is a musculo-tendinous band closely connected below with the aponeurosis on the back of the longissimus dorsi.

Origin.—The erector spinæ, and especially that part which is attached to the two or three lower thoracic and the upper lumbar spines.

Insertion.—The spines of the upper thoracic vertebræ.

Structure.—Upon its posterior surface it is covered by a thick aponeurosis, from the upper edge and anterior surface of which fleshy fibres pass almost directly upwards, and are then inserted by means of four to eight tendons into as many of the upper thoracic spines. They are closely blended with the tendons of the semispinalis dorsi at their insertion.

Nerve-supply.—The posterior branches of the thoracic nerves.

Action.—To extend the thoracic spine.

Relations.—Superficially, the two serrati postici, the latissimus dorsi, the rhomboidei and splenii; externally, the longissimus dorsi; deeply the semispinalis dorsi and complexus.

Variations of the erector spinæ and its divisions.—The number of ribs or vertebræ from which the various parts of these divisions arise, or into which they are inserted, varies much. The insertions upon the lumbar vertebræ are often less numerous than those described. Occasionally the longissimus dorsi receives accessory fibres from the lower ribs. Sometimes the portion of the longissimus dorsi, which arises from the transverse processes of the lower thoracic vertebræ, is separate from the rest of the muscle, and is inserted into the transverse processes of some of the upper thoracic vertebræ.

Sixth Layer

The sixth layer, or rather group, consists of four strata of oblique muscles belonging to the class of transverso-spinales; the deepest stratum being formed by a series of small muscles which run upwards and inwards from the back of one vertebra to that of the next above it; while the other strata run in the same direction but less obliquely, so as to cross over the backs of several vertebræ before reaching their insertion.

1. COMPLEXUS

The **complexus**, or **semispinalis capitis** (fig. 306)—named from the *complex* or complicated arrangement of the muscular bundles which were formerly included under this designation, viz. the complexus, trachelo-mastoid, &c.—is a musculo-tendinous band somewhat constricted about its middle.

Origin.—(1) The back of the articular processes of the cervical vertebræ from the third to the sixth; (2) the back of the transverse processes of the seventh cervical and the six upper thoracic vertebræ; (3) generally also by an inner head from the spine of the seventh cervical vertebra.

Insertion.—The under surface of the occipital bone between the middle and inferior nuchal lines from the middle line for nearly two inches (5 cm.) outwards.

Structure.—Arising by tendinous slips, the fleshy fibres pass upwards and slightly inwards, and are inserted either directly into the occiput or by a short aponeurosis which covers the thick part of the muscle near its outer border. On their way, the innermost fibres are intersected by a transverse tendinous band opposite the sixth cervical spine, and this part of the muscle, being thus divided, is often called the biventer cervicis. There is usually also a smaller tendinous intersection across the posterior surface of the muscle at a higher level.

Nerve-supply.—From the suboccipital and great occipital nerves, and from the internal divisions of the posterior branches of the three or four following cervical nerves which enter the deep surface of the muscle.

Action.—To extend the head, to flex it laterally, and to rotate the face slightly to the opposite side.

Relations.—It is covered by the trapezius and the two splenii, and it lies upon the muscles of the suboccipital triangle and the semispinalis colli, the vertebral artery and the anastomosis between the arteria princeps cervicis and the arteria profunda cervicis. It is pierced by the great occipital nerve. Internally it lies close to the ligamentum nuchæ; and externally, to the trachelo-mastoid and transversalis colli.

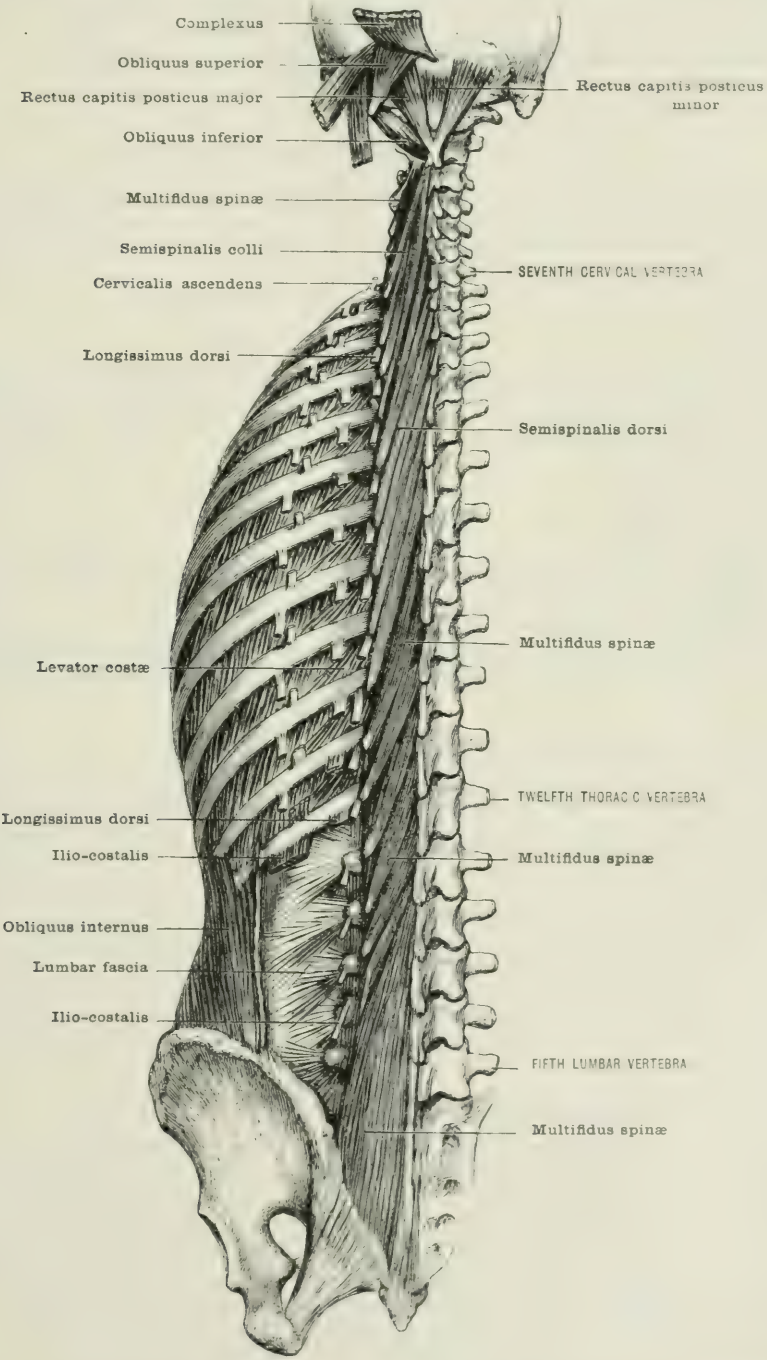
Variations.—The inner head may arise from several of the thoracic spines as well as that of the seventh cervical vertebra. Sometimes a second and smaller complexus runs beneath the normal muscle from the upper thoracic vertebræ to the head.

2. SEMISPINALIS DORSI

The **semispinalis dorsi**—named from the fact that the inner *half* only of the muscle, i.e. its insertion, is attached to the spines of the vertebræ, and from its situation in the dorsal region—is a rather feeble compound muscle, consisting of a series of small muscles with tendinous extremities.

Origin.—The back of the transverse processes of the sixth to the tenth thoracic vertebræ.

FIG. 308.—THE SIXTH LAYER OF THE MUSCLES OF THE BACK.


Complexus
Obliquus superior
Rectus capitis posticus major
Obliquus inferior
Multifidus spinæ
Semispinalis colli
Cervicalis ascendens
Longissimus dorsi
Levator costæ
Longissimus dorsi
Ilio-costalis
Obliquus internus
Lumbar fascia
Ilio-costalis
Rectus capitis posticus minor
SEVENTH CERVICAL VERTEBRA
Semispinalis dorsi
Multifidus spinæ
TWELFTH THORACIC VERTEBRA
Multifidus spinæ
FIFTH LUMBAR VERTEBRA
Multifidus spinæ

Insertion.—The spines of the last two cervical, and first four thoracic vertebræ.

Structure.—Arising by long slender tendons, the fleshy fibres form a thin sheet which runs upwards and inwards, and then breaks up again into short tendons of insertion. Each muscle bridges over six or seven vertebræ.

Nerve-supply.—The internal divisions of the posterior branches of the thoracic spinal nerves.

Action.—To extend and laterally flex the lower cervical and upper thoracic portions of the spinal column. The uppermost tendons will also assist in rotating the lower part of the neck to the opposite side.

Relations.—Superficially, the spinalis and longissimus dorsi; deeply, the multifidus spinæ.

3. SEMISPINALIS COLLI

The **semispinalis colli**—named from the attachment of one-half the muscle, i.e. the insertion, to the spines of the cervical vertebræ—is a somewhat triangular sheet, with a serrated base placed vertically along the transverse processes, and the apex at the spine of the second cervical vertebra.

Origin.—The back of the transverse processes of the five or six upper thoracic vertebræ.

Insertion.—The spines of the second to the fifth cervical vertebræ.

Structure.—Arising by short tendons, the fleshy fibres pass upwards and inwards, bridging over in their course five or six vertebræ, and are inserted by still shorter tendons into the spines of the cervical vertebræ. The highest is by far the largest.

Nerve-supply.—The internal divisions of the posterior branches of the lower cervical nerves, the upper ones entering the muscle on its superficial, and the lower on its deep aspect.

Action.—(1) To extend; (2) to flex laterally; (3) to rotate to the opposite side, the second and following cervical vertebræ.

Relations.—Superficially, the complexus, from which it is separated by branches of the posterior cervical nerves and the anastomosis of the arteria profunda cervicis with the arteria princeps cervicis; deeply, the multifidus spinæ.

4. MULTIFIDUS SPINÆ

The **multifidus spinæ**—named from its many divisions (*multus*, many; *findo*, to cleave)—is a compound muscle, fleshy and thick in the sacral and lumbar regions, but becoming thin and more aponeurotic in the thoracic and cervical regions.

Origin.—(1) The groove in the back of the sacrum, between the spines and the elevations which represent articular processes, the posterior sacro-iliac ligaments, and the deep surface of the tendon of the erector spinæ; (2) the mammillary processes of the lumbar vertebræ; (3) the back of the transverse processes of all the thoracic vertebræ; (4) the articular processes of the fourth to the sixth cervical vertebræ, and the back of the transverse process of the seventh cervical vertebra.

Insertion.—The lower borders of the spines of the vertebræ from the last lumbar to the second cervical.

Structure.—Arising by tendinous fibres superficially, but by fleshy fibres deeply, the bundles of each element of the muscle diverge, the more superficial ones running obliquely upwards and inwards so as to bridge three vertebræ, while the deeper ones pass more transversely to the third, second, and in the neck, the next vertebra above. Consequently, the more superficial fibres from one vertebra overlap the deeper ones from some of the vertebræ above.

Nerve-supply.—The internal divisions of the posterior branches of the spinal nerves from the second cervical to the third sacral.

Action.—To extend, laterally flex, and to rotate to the opposite side, the various parts of the spinal column.

Relations.—Superficially, the erector spinæ, longissimus and spinalis dorsi, the semispinalis dorsi and colli; deeply, the rotatores spinæ.

5. ROTATORES SPINÆ

The **rotatores spinæ**—named from the rotatory action which they impress upon the spine—are small rhomboidal sheets, chiefly found in the thoracic region, where they form a series of eleven pairs, but occasionally found also in the upper lumbar and the lower cervical regions.

Origin.—The back and upper border of the transverse process.

Insertion.—The lower border of the lamina of the next vertebra above.

Structure.—Sheets of parallel fibres, almost entirely fleshy, which run upwards and inwards.

Nerve-supply.—The internal divisions of the posterior primary branches.

Action.—To rotate to the opposite side, and also to extend and laterally flex, the vertebra which receives its insertion.

Relations.—Superficially, the multifidus spinæ; deeply, the ligamenta subflava.

Seventh Layer

The seventh group consists of short vertical muscles, the interspinales and intertransversales, which lie on a deep plane internal and external to the transversospinales, and under cover of the longer vertical muscles which form the fifth layer of the back.

1. INTERSPINALES

The **interspinales**—named from their position—are small ribbon-like muscles which run vertically between the spines, especially in the cervical and lumbar regions.

Origin.—The upper surface of the spine of the vertebra, near its tip.

Insertion.—The posterior part of the lower surface of the spine of the vertebra above.

Structure.—In the neck the bundles are attached to the two parts of the bifid extremities of the spines from the axis downwards. In the lumbar region they form broader bands attached to the whole length of the spines, and separated by the interspinous ligaments.

Nerve-supply.—The internal divisions of the posterior branches of the spinal nerves.

Action.—To extend the vertebra next above.

Relations.—Behind, the spinales and complexus; internally, the interspinous ligaments; externally, the multifidus spinæ.

Variations.—Occasionally they pass over one spine to be inserted upon the next but one. The spinalis colli, when present, may be looked upon as a still greater extension of this variation.

2. INTERTRANSVERSALES

The **intertransversales**—named from their position between the transverse processes—are small vertical bands, also found chiefly in the cervical and lumbar regions.

In the neck (fig. 316) they are double, the anterior band connecting the anterior tubercles of the transverse processes of the cervical vertebræ, and the posterior the posterior tubercles.

In the lumbar region they are also double, an outer set connecting the adjacent surfaces of the ends of the transverse processes, and an inner connecting the accessory tubercle of one vertebra to the mammillary tubercle of the next vertebra below. A few similar pairs of muscles may also be found in the lower part of the thoracic region.

Structure.—Fleshy, with parallel fibres.

Nerve-supply.—The spinal nerves as they emerge from the intervertebral foramina.

Action.—To flex laterally the spinal column.

Relations.—In the neck, the anterior primary branches of the nerves come out between the anterior and posterior intertransversales, and the posterior primary branches emerge at the inner borders of the posterior intertransversales. They are hidden from view by the mass of muscles attached to the transverse processes. In the lumbar region they lie under cover of the erector spinæ and its divisions, and they are covered in front by the psoas (fig. 286).

THE SUBOCCIPITAL MUSCLES

The suboccipital group consists of short muscles, situated in the same plane as the preceding, but somewhat altered in their arrangement on account of the peculiar movements of the region. They are the rectus capitis posticus major and minor, the obliquus capitis inferior and superior, the rectus capitis lateralis.

1. RECTUS CAPITIS POSTICUS MAJOR

The **rectus capitis posticus major** (fig. 308)—somewhat incorrectly named from the direction of its fibres, its position, and size—is a triangular sheet.

Origin.—The upper surface of the spine of the axis along its side and one-half of its bifid tip.

Insertion.—The middle third of the inferior nuchal line of the occipital bone.

Structure.—From a narrow tendinous origin the fleshy fibres diverge as they run upwards and outwards to a broad insertion.

Nerve-supply.—A branch of the suboccipital which enters the middle of its superficial surface.

Action.—To extend the head upon the neck; and to rotate the head to the same side.

Relations.—Behind, the complexus and obliquus superior; in front, the succeeding muscle.

2. RECTUS CAPITIS POSTICUS MINOR

The **rectus capitis posticus minor** (fig. 308)—named from its direction, size, and position—is also flat and triangular.

Origin.—The upper part of one-half of the posterior tubercle of the atlas.

Insertion.—The inner third of the inferior nuchal line of the occipital bone, and the space immediately in front of it.

Structure.—Fleshy, and consisting of fibres which diverge in fan shape as they pass upwards and outwards.

Nerve-supply.—Branches of the suboccipital nerve which enter the outer part of its superficial surface.

Action.—To extend the head on the neck.

Relations.—Behind, the preceding muscle and complexus; in front, the posterior occipito-atlantal ligament.

3. OBLIQUUS CAPITIS INFERIOR

The **obliquus capitis inferior** (fig. 308)—named from its direction and position—is a fusiform sheet.

Origin.—The upper part of the side of the spine of the axis.

Insertion.—The lower part of the tip of the transverse process of the atlas.

Structure.—Strong and fleshy, with pointed extremities, and a general direction upwards and outwards.

Nerve-supply.—The suboccipital, which sends branches to its upper border.

Action.—Chiefly to rotate the atlas, and with it the head, to the same side. It will also help in extension and lateral flexion of the atlas upon the axis.

Relations.—Behind, the complexus and the great occipital nerve, which winds round its lower border; in front, the posterior atlanto-axial ligament and vertebral artery.

4. OBLIQUUS CAPITIS SUPERIOR

The **obliquus capitis superior** (fig. 308)—named from its direction and position—is flat and triangular.

Origin.—The back of the upper surface of the transverse process of the atlas.

Insertion.—The impression immediately behind the outer half of the inferior nuchal line of the occipital bone.

Structure.—Of fleshy fibres which diverge fanwise upwards and inwards.

Nerve-supply.—The suboccipital, which supplies it at the inner part of its deep surface.

Action.—To extend and slightly to flex laterally the head.

Relations.—Behind, the complexus and splenius capitis; in front, the rectus capitis posticus major, vertebral artery, and posterior occipito-atlantal ligament.

5. RECTUS CAPITIS LATERALIS

The **rectus capitis lateralis** (fig. 316)—named from its direction and position—is a quadrilateral sheet, and corresponds to the intertransversales posteriores of the vertebræ below.

Origin.—The front of the upper surface of the lateral mass of the atlas.

Insertion.—The under surface of the jugular process of the occipital bone.

Structure.—Fleshy, with parallel vertical fibres.

Nerve-supply.—The anterior branch of the first cervical nerve which passes out internal to it, and supplies it from the front.

Action.—To flex the head laterally.

Relations.—In front, the anterior primary branch of the first cervical nerve, and the internal jugular vein; behind, the obliquus superior and the trachelomastoid.

Variations.—Occasionally the short muscles of this group are double. Small slips of muscle have been observed, running from the spines of the lower cervical vertebræ, or the ligamentum nuchæ to the occipital bone.

MUSCLES OF THE HEAD AND NECK

The superficial layer in this region is peculiar in that it consists of numerous muscles contained in the connective tissue outside the deep fascia. This connective tissue, the **superficial fascia**, is moderately provided with fat, and extends without any deep connection to the adjacent regions of the thorax, arm, and back. In the scalp it is firm and difficult to dissect on account of numerous septa which pass through it to unite the skin to the subjacent muscular aponeurosis. In this situation the superficial fascia is richly provided with blood by vessels which run within it instead of beneath the deep fascia, which is their usual position in other parts of the body.

Besides the peculiarity of their position outside the deep fascia, these muscles are all associated in their function, viz. to produce the various movements of the features by which the expression of the emotions is effected. They are also peculiar in the fact that many of them decussate with one another on the way to their insertion in the skin; and they are all supplied by the seventh pair of cranial nerves.

SUPERFICIAL MUSCLES OF NECK AND SCALP

1. PLATYSMA MYOIDES

The **platysma myoides**—named from its flat expanse (*platysma*, a plate) and its similarity to muscle (*myoides*, like muscle, for the older anatomists considered it to be only a membrane)—is a quadrilateral sheet with a somewhat toothed posterior border.

Origin.—(1) The deep fascia of the upper part of the front of the chest and the shoulder, and the deep cervical fascia covering the sterno-mastoid.

Insertion.—(1) The outer surface of the lower border of the body of the mandible, both on the same and the opposite side; (2) the deep surface of the skin from the corner of the mouth to the anterior border of the masseter muscle.

Structure.—Arising by slender bundles from the fascia covering the pectoralis major and deltoid, in a line from the second costal cartilage to the tip of the acromial process, the pale muscular fibres at first converge slightly until they have crossed the clavicle. They then run parallel to one another upwards and forwards, receiving at the posterior border of the muscle small teeth from the deep fascia forming the sheath of the sterno-mastoid. The anterior fibres cross the middle line half-way between the hyoid bone and the symphysis, and are inserted into the lower border of the body of the mandible upon the opposite side of the neck. The greater part of the rest are inserted into the outer surface of the lower border of the mandible on the same side, but some are continued upwards and join with the depressor labii inferioris. Still further back, a few fibres pass upwards over the lower part of the masseter, and are inserted into the deep surface of the skin just outside the angle of the mouth. A strong bundle of these fibres which runs nearly transversely forwards to the corner of the mouth will be described later as the risorius muscle. In its whole extent, the muscle is closely connected with the deep surface of the skin.

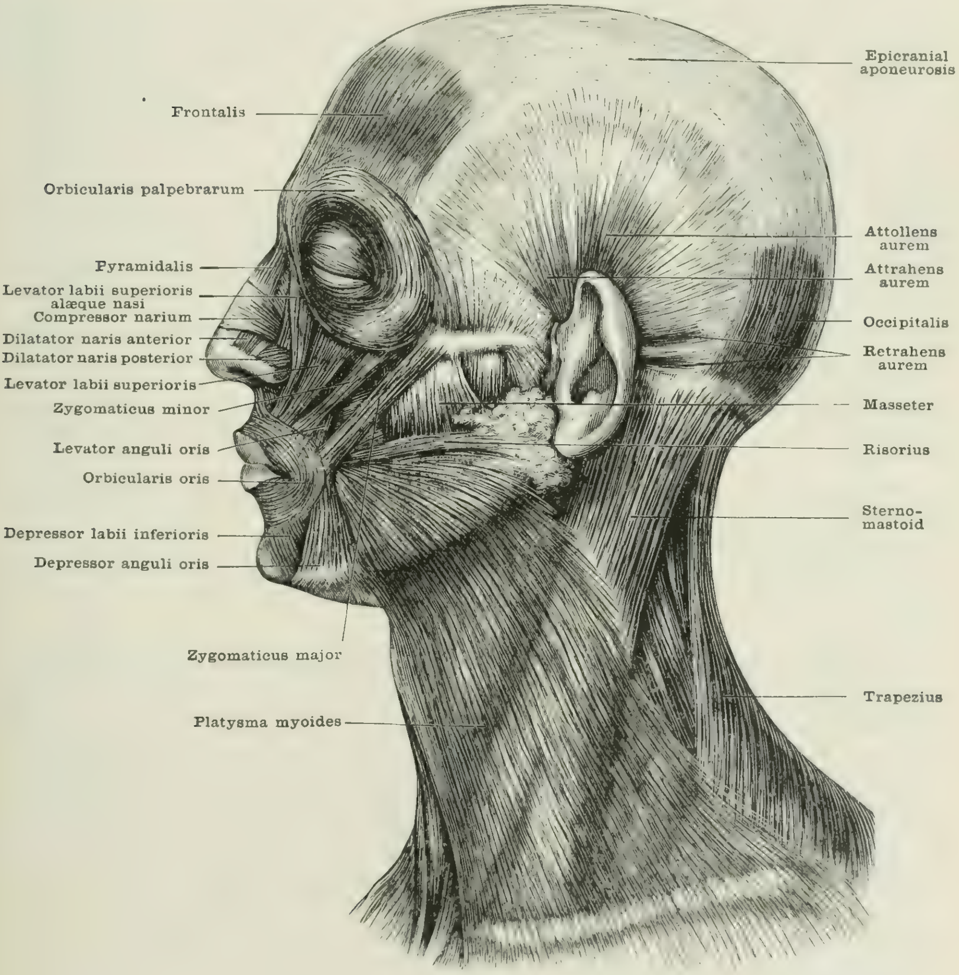
Nerve-supply.—The seventh cranial nerve, by means of the inframandibular branch of the cervico-facial division, which supplies it from beneath at a point a little below the angle of the mandible.

Action.—(1) To draw downwards and outwards the lower lip, by means of the fibres which are continued upwards into the depressor labii inferioris. In transverse wounds below the mandible, the division of this muscle often impairs this movement. Duchenne has shown how important a part this depression of the lower lip discharges in the expression of horror or extreme surprise. (2) To draw outwards the soft parts of the side of the neck, so as to diminish pressure upon the veins during strong inspiratory efforts. As the muscle is arched in its passage from the clavicle to the mandible, with the concavity directed outwards, it is plain that its contraction will flatten the arch and tend to lift the skin and fasciæ off the vessels, in exactly the opposite manner to that by which pressure is exerted when the concavity is upon the deep surface of a muscle. (3) It may assist feebly in depression of the mandible; and, if that be fixed, in flexion of the head and rotation towards the same side. This muscle covers all the front of the neck with the exception of a narrow triangular interval, the base of which is formed by the upper border of the sternum and the adjacent sterno-clavicular joints.

Relations.—It lies immediately beneath the skin and superficial fascia, and in a lean neck the bundles are often distinctly visible through the skin, especially when an effort is made to depress the lower lip while the teeth are clenched. A thin band derived from the anterior part of the depressor anguli oris usually crosses it superficially beneath the chin (page 438). Upon its deep surface lie the deep cervical fascia, the external jugular vein, the glandulæ concatenatæ of the neck, the parotid and submaxillary glands, and the superficial branches of the cervical plexus, together with the masseter, and buccinator, the muscles of the front and side of the neck, and the pectoralis major and deltoid. Its anterior border lies externally to the sterno-clavicular joint, and is often conspicuous in the aged, in whom the two muscles may be seen to hang, like a dewlap, beneath the chin, and then to divide into the two separate folds formed by their internal borders, which run outwards and downwards towards the clavicles.

Variations.—The anterior border of the muscle may be placed as far backwards as the middle of the clavicle, and in some cases the muscle has been entirely absent. Slips have been seen going to the side of the thyroid cartilage, the auricle or the mastoid process.

FIG. 309.—THE SUPERFICIAL MUSCLES OF THE HEAD AND NECK.


Epicranial aponeurosis
Frontalis
Orbicularis palpebrarum
Attollens aurem
Pyramidalis
Attrahens aurem
Levator labii superioris alæque nasi
Compressor narium
Occipitalis
Dilatator naris anterior
Dilatator naris posterior
Retrahens aurem
Levator labii superioris
Masseter
Zygomaticus minor
Levator anguli oris
Risorius
Orbicularis oris
Sterno-mastoid
Depressor labii inferioris
Depressor anguli oris
Zygomaticus major
Trapezius
Platysma myoides

2. OCCIPITO-FRONTALIS

The **occipito-frontalis**—named from its two muscular bellies, which cover parts of the occipital and frontal bones—consists of two curved muscular sheets united by a strong aponeurosis, and is best described in three parts—viz. the **occipitalis** and **frontalis muscles** and the **epicranial aponeurosis**.

(1) The **occipitalis** is a small quadrilateral sheet.

Origin.—(1) The outer two-thirds of the superior nuchal line of the occipital bone, and (2) a ridge upon the mastoid process.

Insertion.—The posterior border of the epicranial aponeurosis, about one inch and a half (3·7 cm.) above the superior nuchal line of the occipital bone.

(2) The **frontalis**—a curved sheet of somewhat quadrilateral shape, with a convex upper, and a concave lower border.

Origin.—The epicranial aponeurosis, about half-way between the coronal suture and the orbital arch.

Insertion.—The deep surface of the skin of the eyebrow and of that which occupies the space at the root of the nose between the eyebrow and the middle line.

(3) The **epicranial aponeurosis** forms the central tendon of the occipito-frontalis, and its attachments will be described with the structure of the muscle.

Structure.—The occipitalis is thin and pale, and arises by short tendinous intermingled with muscular fibres, and, after passing in parallel lines for about one inch and a half (3·7 cm.) upwards, it is inserted into the epicranial aponeurosis, a strong curved sheet, which occupies the whole of the surface of the skull from the superior nuchal lines behind to the eyebrows in front, and is continued laterally over the temporal fascia of either side to about the level of the external auditory meatus. Above, it is tendinous, and composed of fibres which run from behind forwards. It is thin in front and behind, where it forms a sort of sheath to the occipitalis and frontalis muscles; but near the median line behind, it is thick where it fills up the interval between the occipitales. Laterally, it becomes very thin, and is lost in the loose connective tissue superficial to the temporal fascia after having given origin to the attrahens and attollens aurem muscles. In front, a narrow triangular slip, with the base upwards and the apex between the eyebrows, is left between the frontales, which are larger and somewhat thicker than the occipitales. The fibres of the frontales run in parallel bundles downwards and slightly inwards, and are lost in the subcutaneous fat of the eyebrows; while near the middle line a small slip is continued upon the bridge of the nose as the *pyramidalis*, after entering into close relation with the deep surface of the skin at the junction of the forehead and nose.

Nerve-supply.—The *occipitalis* receives one of the divisions of the posterior auricular branch from the facial or seventh cranial nerve. Its filaments enter the deep surface of the muscle close to the outer border.

The **frontalis** is supplied by the temporal branch of the temporo-facial division of the facial nerve which is distributed to the deep surface near its outer border.

Action.—The occipitales draw back the epicranial aponeurosis, and with it the scalp, which is intimately attached to its superficial aspect. Acting from behind, the frontales raise the eyebrows. If these are fixed by the contraction of the orbicularis palpebrarum, the frontalis will draw forwards the epicranial aponeurosis and scalp. When both occipitales and frontales contract, they raise the eyebrows to the utmost extent, and throw the skin of the forehead into transverse wrinkles, as in the expression of surprise or horror. At the same time, on account of the direction of the hair-bulbs, which lie with a forward slant behind and a backward slant in front, there will be a tendency to lift the hair shafts, and to make them 'stand on end, like quills upon the fretful porcupine.'

When the frontalis alone contracts, taking its fixed point from above, a slight elevation of the eyebrow is produced, as in the expression of attention. This is also accompanied by a transverse wrinkling of the forehead.

Relations.—Superficially, the epicranial aponeurosis and its muscles are in very close connection with the skin of the scalp and forehead, being only separated from it by granular fat which is contained in small compartments formed by fibrous septa extending from the aponeurosis to the deep surface of the skin. In the fat lie the hair-bulbs and blood-vessels of the scalp. Beneath, it is separated from the pericranium and temporal fascia by very loose connective tissue.

Variations.—The occipitalis may be continuous with the retrahens aurem. The frontalis may have insertions into the external or internal angle of the frontal bone, the nasal process of the maxilla, or the nasal bone.

THE MUSCLES OF THE EYELIDS AND EYEBROWS

These are four in number—viz. the orbicularis palpebrarum, the tensor tarsi, the corrugator supercilii, and the levator palpebræ superioris. To these may be added a fifth, the frontalis, which has been described. The levator palpebræ superioris will be described with the orbital muscles. The only part of it which is visible in a dissection of the face is its broad expansion, which is intimately blended with the front of the crescentic plate of condensed fibrous tissue called the **upper tarsal cartilage.**

1. ORBICULARIS PALPEBRARUM

The **orbicularis palpebrarum**—named from the rounded shape of the majority of its fibres (*orbiculus*, a little circle) and its relation to the eyelids—is an oval sheet with a long transverse diameter and so curved as to fit the prominences and depressions of the eyelids and the margin of the orbit.

It consists of a marginal and a central division: the former stronger and called the *orbital* portion; the latter thin and pale, and called the *palpebral* portion. Both have attachments to the tarsal ligaments, by which the so-called tarsal cartilages are fastened to the margins of the orbit. The **internal tarsal ligament,** or **tendo oculi,** is a strong flat band of fibrous tissue about a sixth of an inch (4 mm.) long with surfaces which look upwards and downwards. It arises from a projection upon the crest of the nasal process of the maxilla, and passes transversely outwards and somewhat upwards in front of the lachrymal sac, to which it gives off an aponeurotic covering. It then bifurcates into an upper and a lower division, which diverge to be attached to the inner extremities of the tarsi, here separated by the *caruncula lachrymalis.* The **external tarsal ligament** is undivided; it passes from the margin of the frontal process of the malar bone transversely inwards to the extremities of the tarsi, which at the outer commissure of the eyelids are in close contact.

The **orbital** portion of the orbicularis palpebrarum consists of a series of concentric oval loops which are attached only at the inner side of the orbit.

Origin and insertion.—(1) The lower part of the internal angular process of the frontal bone; (2) the posterior half of the outer surface of the nasal process of the maxilla; (3) the upper and lower surfaces of the inner half of the internal tarsal ligament.

The **palpebral portion** consists of paler and shorter semielliptical fibres.

Origin.—The upper and lower surfaces of the outer half of the internal tarsal ligament, together with the adjacent part of the aponeurosis covering the lachrymal sac.

Insertion.—The upper and lower surfaces of the external tarsal ligament.

Structure.—Both portions of the muscle are entirely composed of fleshy fibres. In addition to the origin of the orbital portion at the inner part of the orbit, it gives off processes from its circumference which blend with the adjacent muscles, such as the frontalis and the elevator of the upper lip. Moreover, some of the deeper fibres of the muscle decussate with the fibres of those adjacent muscles which lie under cover of the outer loops.

The innermost fibres of the palpebral portion are shorter than the rest and, instead of extending across the whole length of the tarsi, they terminate upon their free margins, between the attachment of the eyelashes and the orifices of certain glands which line the inner surface of the tarsi.

Nerve-supply.—The temporal and malar branches of the temporo-facial division of the facial nerve, which enter the outer part of the muscle upon its deep surface.

Action.—(1) The orbital portion by its contraction draws the soft parts around the opening of the orbit inwards and towards the palpebral aperture, raising a ridge which deepens the socket of the eye so as to protect the eyeball from injury, e.g. from the blow of a fist; (2) Its upper part will lower the eyebrow, as when the face is exposed to a strong light, or when the mind is wrapt in thought. (3)

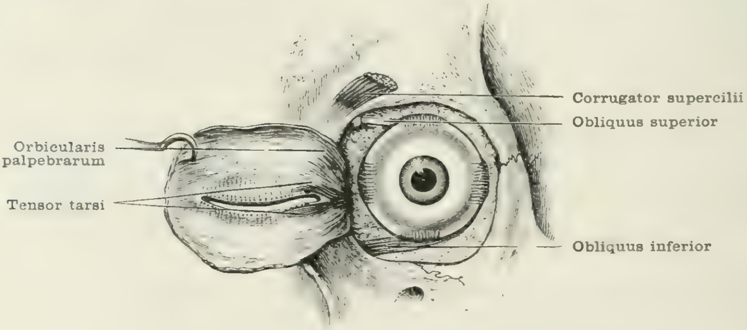
The palpebral portion will lower the upper and raise the lower eyelid, in closure of the eye. (4) The firm contraction of the whole muscle presses upon the eyeball, and supports it from the evil effect of a strong expiratory effort, which by the rush of blood into the interior of the eyeball might burst its thin-walled vessels, and do serious harm to the delicate structures within. Thus it will be noticed that in shouting, sneezing, or violent coughing the eyes are tightly closed. (5) By pressure upon the lachrymal gland it is probable that the muscle influences the secretion of tears: hence their flow during violent coughing or laughter. It will also draw outwards and forwards the covering of the lachrymal sac, and so produce a suction of the tears through the canaliculi into the sac.

Relations.—Superficially, the skin; upon its deep surface the tarsal cartilages and their ligaments, the palpebral ligaments and the expansion of the tendon of the levator palpebræ superioris; the bones which bound the opening of the orbit, the frontalis and corrugator supercilii muscles above; the temporal fascia externally; the zygomaticus minor, levator labii superioris, and levator labii superioris alæque nasi, below; also the supraorbital vessels and nerve, the supratrochlear nerve, the terminal portion of the facial artery, and the palpebral branches of the infraorbital vessels and nerve.

2. TENSOR TARSI

The **tensor tarsi**—named from its supposed action upon the tarsus—is a small muscle composed of two flat slips, which are closely connected with the preceding muscle.

Fig. 310.—The Tensor Tarsi and Corrugator Supercilii.



Origin.—The crest of the lachrymal bone.

Insertion.—The posterior aspect of the inner end of the tarsi.

Structure.—Arising as a thin muscular sheet, at the back of, and in close contact with, the outer surface of the lachrymal sac, the muscle divides into two slips which run behind the canaliculi, and are inserted into the edge of the eyelids near the puncta lachrymalia.

Nerve-supply.—From the infraorbital branch of the upper division of the facial nerve, by small slips which enter the muscle near its lower border.

Action.—To compress the lachrymal sac by drawing inwards and backwards the outer part of the tendo oculi and the inner ends of the tarsi.

Relations.—Internally and in front, the lachrymal sac; externally and behind, the orbital fat from which it is separated by the capsule of Tenon.

3. CORRUGATOR SUPERCILII

The **corrugator supercilii**—named from its action, the wrinkling of the brow—is a short ribbon-shaped muscle.

Origin.—The inner extremity of the superciliary ridge of the frontal bone.

Insertion.—The deep surface of the skin at the middle of the eyebrow.

Structure.—A small wisp of fleshy fibres, closely connected with the orbital portion of the orbicularis palpebrarum. It passes outwards, and at the same time slightly upwards and forwards, to the under surface of this muscle, and, diverging slightly, its fibres pass between the interlacing fibres of the orbicularis and frontalis to their insertion into the skin.

Nerve-supply.—The temporal branch of the upper division of the facial nerve, which enters its deep surface from the outer side.

Action.—To draw the middle of the eyebrow inwards and slightly downwards. In the adult this causes vertical wrinkles to form between the eyebrows, and gives a frowning aspect to the face, as when a difficulty occurs either in thought or action. In the crying infant, the effect of its contraction is to cause dimples about the centre of the eyebrows, which may usually be observed just before the orbiculares palpebrarum close the eyes.

Relations.—Superficially, the orbicularis palpebrarum; deeply, the frontal bone.

For The Muscles of the Eye, see pages 854–7.

THE EXTRINSIC MUSCLES OF THE AURICLE

The **extrinsic muscles of the auricle** (fig. 309)—viz. the attollens aurem, the attrahens aurem, and the retrahens aurem—are feeble, and almost vestigial in man. They are closely connected with the occipito-frontalis. The largest of the three is the attollens aurem.

1. ATTOLLENS AUREM

The **attollens aurem**—named from its action as an elevator of the auricle—is a thin triangular sheet.

Origin.—The epicranial aponeurosis, a short distance below the top of the temporal ridge.

Insertion.—The inner surface of the pinna of the auricle, over a space which corresponds to the fossa of the antihelix upon its outer surface.

Structure.—A thin, fan-shaped sheet, consisting of muscular fibres and bands of connective tissue, which all converge from above upon a flat tendon just above the point of insertion.

Nerve-supply.—The temporal branch of the upper division of the facial nerve, by filaments which enter the front of the deep surface.

Action.—To draw upwards the auricle.

Relations.—Superficially, the skin; deeply, the temporal fascia and auriculo-temporal nerve.

2. ATTRAHENS AUREM

The **attrahens aurem**—named from its action in drawing forwards the auricle—is a smaller and very thin triangular sheet.

Origin.—The lateral border of the epicranial aponeurosis in front of and below the level of the preceding, with which it is usually continuous.

Insertion.—The front of the inner surface of the helix.

Structure.—It consists of a thin stratum of muscular fibres, intermingled with connective tissue, lying upon the temporal fascia, and converging backwards and downwards upon a feeble flat tendon.

Nerve-supply.—The same as the preceding.

Action.—To draw forwards and upwards the auricle.

Relations.—Superficially, the skin; deeply, the temporal fascia, temporal artery, and auriculo-temporal nerve.

3. RETRAHENS AUREM

The **retrahens aurem**—named from its action of drawing back the auricle—consists of two muscular bands, which narrow slightly as they pass forwards to the ear.

Origin.—The upper part of the outer surface of the mastoid process of the temporal bone.

Insertion.—The inner surface of the concha.

Structure.—It consists usually of darker and more distinctly fleshy bands than the two preceding muscles. They arise, one above the other, by short tendinous fibres from the mastoid process, and pass transversely forwards to their tendinous insertion.

Nerve-supply.—The posterior auricular branch of the facial, which sends filaments to the lower part of its deep surface.

Action.—To draw back the auricle.

Relations.—Superficially, the skin; deeply, the posterior auricular artery, part of the great auricular and the posterior auricular nerves.

THE MUSCLES OF THE NOSE

The chief muscles of the nose are three in number: viz. the pyramidalis nasi and compressor narium, which consist of muscular fibres which pass upwards and outwards from an aponeurosis, covering the cartilaginous part of the ridge of the nose, and intimately connected with the under surface of the skin; and the depressor alæ nasi. A small slip from the levator labii superioris alæque nasi is also attached to the ala nasi; and two little muscles may sometimes be found in the subcutaneous tissue upon the outer surface of the nostril: viz. the dilatator naris anterior and posterior.

1. PYRAMIDALIS

The **pyramidalis** (figs. 309 and 311)—named from its triangular shape, which is like the side of a pyramid—is a thin sheet.

Origin.—The upper border of the nasal aponeurosis over the junction of the cartilage with the lower border of the nasal bone.

Insertion.—The deep surface of the skin between the eyebrows, being at this point continuous with the inner fibres of the frontalis.

Structure.—The muscular fibres form a slightly curved sheet, which wraps round the anterior surface of the nasal bone, and is continuous with the corresponding muscle of the other side. They converge as they pass upwards, and the outer ones run slightly inwards as well as upwards, to their insertion.

Nerve-supply.—The infraorbital branch of the upper division of the facial, which enters the outer part of its deep surface.

Action.—To draw downwards the skin between the eyebrows, so as to throw it forwards into a fold, and at the same time to produce a transverse groove above the bridge of the nose. This gives to the face a stern, aggressive, or fierce expression.

Relations.—Superficially, the skin; and deeply, the nasal bone.

Variation.—This muscle is sometimes absent.

2. COMPRESSOR NARIUM

The **compressor narium** (figs. 309 and 311)—named from its supposed action as a compressor of the nostrils—is a triangular sheet, the base of which is attached to the nasal aponeurosis above mentioned.

Origin.—The sides of the nasal aponeurosis.

Insertion.—(1) The lower and front part of the canine fossa of the maxilla; (2) part of its fibres are continued into those of adjacent muscles, especially the levator labii superioris alæque nasi, and the levator anguli oris.

Structure.—Arising from the side of the aponeurosis in a vertical line about half an inch (1·2 cm.) from the ridge of the nose, the fibres of the muscular sheet converge as they pass backwards, outwards and downwards to a narrow band just above and behind the ala nasi. Here they are partly attached to the maxilla, and partly they pass into the adjacent muscles.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve, which sends filaments to the deep surface of the muscle near its upper border.

Action.—(1) To depress slightly the cartilaginous ridge of the nose; (2) to throw into vertical wrinkles the side of the nose, as when a bad smell is perceived; (3) to assist the adjacent muscles in dilating the nostril and drawing up parts of the upper lip.

Relations.—Superficially, the skin and levator labii superioris alæque nasi; deeply, the cartilages of the nose.

3. DEPRESSOR ALÆ NASI

The **depressor alæ nasi** (fig. 311)—named from its action upon the cartilage of the nostril—is a small triangular sheet.

Origin.—The incisive fossa of the maxilla.

Insertion.—(1) The lower and back part of the cartilage of the ala nasi; (2) the adjacent part of the lower border of the cartilaginous septum nasi.

Structure.—Its muscular fibres diverge upwards and outwards from their origin.

Nerve-supply.—Small filaments from the buccal branch of the lower division of the facial nerve, which enter the muscle near its outer border.

Action.—To draw downwards and inwards the alar cartilage.

Relations.—Superficially, the orbicularis oris; deeply, the maxilla. It is also closely connected with the fibres of the previous muscle and the elevators of the upper lip.

4. LEVATOR LABII SUPERIORIS ALÆQUE NASI

This muscle will be described with the Muscles of the Mouth.

5. DILATATOR NARIS ANTERIOR

The **dilatator naris anterior** (fig. 309)—named from its action and position—is a small quadrilateral sheet.

Origin.—The lower edge of the lateral cartilage of the nose.

Insertion.—The deep surface of the skin covering the ala nasi.

Structure.—A thin stratum of muscle, which may occasionally be found passing downwards upon the upper part of the alar cartilage.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve.

Action.—To dilate the nostril, e.g. in the expression of anger, or in hard breathing.

Relations.—Superficially, the skin below and the compressor narium above; deeply, the cartilages of the ala.

6. DILATATOR NARIS POSTERIOR

The **dilatator naris posterior** (fig. 309)—named from its action and position—is a similar sheet of somewhat quadrilateral shape.

Origin.—(1) The edge of the nasal aperture of the maxilla; and (2) the outer surface of the sesamoid cartilages of the nose.

Insertion.—The skin over the posterior and lower part of the alar cartilage.

Structure.—A thin stratum of parallel muscular fibres running forwards and downwards.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve.

Action.—To dilate the nostril.

Relations.—Superficially, the skin and levator labii superioris alæque nasi; deeply, the sesamoid cartilages.

MUSCLES OF THE MOUTH

The muscles of the mouth consist, first, of the orbicularis oris, which is the sphincter surrounding the aperture; and secondly, of the bands which radiate from this, as a centre, to their origin upon the adjacent facial bones. These may be grouped into three sets: viz. (1) the **transverse** series, which radiate transversely. This consists of only one pair of muscles, the buccinators. (2) The **angular** series, which pass from above or below to the corner of the mouth. (3) The **labial** series, which pass nearly vertically either downwards or upwards to the lips, and chiefly to their inner half.

A fourth series may be added, which have no special connection with the mouth, viz. two nearly vertical muscles close to the middle line, which radiate from an origin close to the mouth. Of these, one has already been described, the depressor alæ nasi; the other arises from the lower jaw, the levator menti.

The muscles might also be arranged according to their stratification, for they form two, and, in some parts, three layers over the greater part of this region.

1. ORBICULARIS ORIS

The **orbicularis oris**—an unpaired muscle, named from its shape and situation—is an oval sheet with the long axis placed transversely, and its fibres arranged round a transverse central aperture. Like the orbicularis oculi, the muscle may be divided into an *internal* or *labial* portion, and an *external* or *facial*. The first part, which is superficial, has no bony connection, except through the medium of the adjacent muscles with which it is closely blended. The second, which is deep and which forms part of the third layer of the facial muscles, has the following small attachments to bone and cartilage.

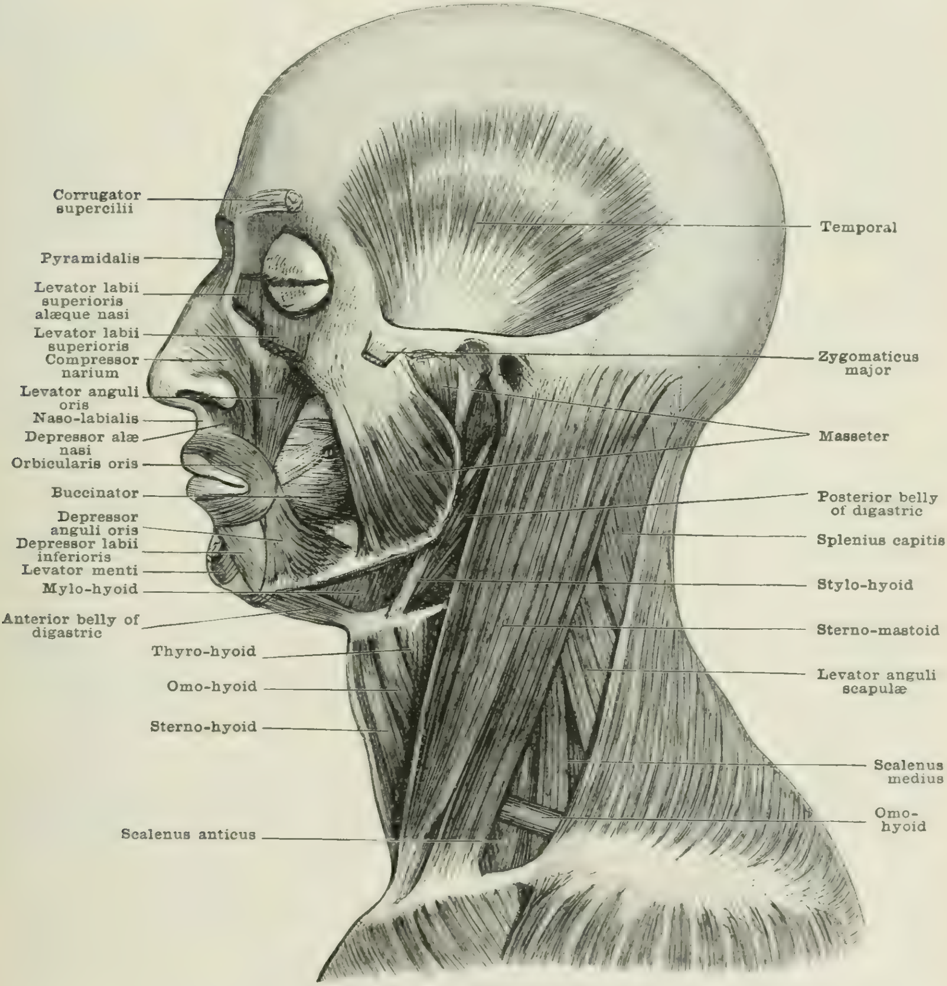
Attachments to bone and cartilage.—(1) Naso-labial slips from the back of the lower part of the cartilage of the septum of the nose; (2) the incisive fossa of the maxilla just above the socket of the lateral incisor tooth; (3) the incisive fossa of the mandible, below the sockets of the lateral incisor and canine teeth.

Structure.—The orbicularis oris consists of three sets of fibres, which are in their direction approximately **transverse, vertical,** and **sagittal** or **antero-posterior.** The **transverse set** form the most conspicuous part of the muscle; they are continuous on either side with the fibres of the buccinator, and they constitute the greater part of the fine smooth bundles which lie beneath the red skin of the prolabium, and are called the **labial portion** of the muscle. The **vertical fibres** are derived from the elevators and depressors of the lips, including the zygomatici; they form the superficial part of the **facial portion,** and they interlace with the transverse fibres. Many of them pass round the corners of the mouth and become transverse; those arising from the maxilla and its vicinity passing to the lower lip, while those from the mandible go to the upper. The **sagittal or antero-posterior fibres** pass directly or somewhat obliquely from before backwards between the transverse fibres, and unite the skin to the mucous membrane. They are found chiefly in the **labial portion** of the muscle. The two naso-labial slips pass side by side vertically downwards to the upper part of the muscle, their position being indicated upon the surface by two small vertical ridges which descend from the columna nasi on either side of the median groove of the upper lip. The fleshy slips from the maxilla and mandible—the **musculi incisivi**, as they are called—pass outwards and forwards to join the deep surface of the transverse fibres near the corners of the mouth.

Nerve-supply.—The buccal and supramaxillary branches of the lower division of the facial, which enter the facial part of the muscle near its outer border.

Action.—(1) To bring together the lips and to oppose all the other muscles which converge upon the mouth, and tend to draw it open in various directions. It thus acts negatively, and prevents the expression of any emotion, as when the lips are pursed up. If the upper fibres alone act, the upper lip will be drawn downwards; if the lower, the lower lip will be drawn upwards. If the fibres of the labial portion contract strongly, the corners of the mouth are approximated. (2) To shoot out the lips: this will chiefly depend upon the contraction of the facial portion and the musculi incisivi. (3) To press the lips against the teeth: the plane of the muscle being curved, with the concavity against the arches formed by the front teeth, its contraction will carry the food backwards into the oral cavity.

FIG. 311.—THE DEEPER LAYER OF THE MUSCLES OF THE FACE AND NECK.


Corrugator supercilii
Pyramidalis
Levator labii superioris alæque nasi
Levator labii superioris
Compressor narium
Levator anguli oris
Naso-labialis
Depressor alæ nasi
Orbicularis oris
Buccinator
Depressor anguli oris
Depressor labii inferioris
Levator menti
Mylo-hyoid
Anterior belly of digastric
Thyro-hyoid
Omo-hyoid
Sterno-hyoid
Scalenus anticus
Temporal
Zygomaticus major
Masseter
Posterior belly of digastric
Splenius capitis
Stylo-hyoid
Sterno-mastoid
Levator anguli scapulæ
Scalenus medius
Omo-hyoid

Relations.—In front of the labial portion is the bright red skin of the prolabium; and in front of the facial portion lie the angular and labial series of muscles, together with some subcutaneous fat.

Upon the deep surface lies the mucous membrane of the mouth, separated from the muscular fibres by the mucous and small salivary glands, together with the superior and inferior coronary arteries.

TRANSVERSE MUSCLES OF THE MOUTH

This group comprises only the buccinator.

BUCCINATOR

The **buccinator**—named from its action, as it is the muscle used by the trumpeter (*buccinator*)—is a somewhat oval sheet of muscular fibre, distinct in its origin, but blending in front with the orbicularis oris. It forms a part of the third stratum of the facial muscles.

Origin.—(1) The outer surface of the alveolar process of the maxilla above the molar teeth; (2) the anterior border of the pterygo-maxillary ligament, a fibrous band or raphé extending from the hamular process of the internal pterygoid plate of the sphenoid bone to the back of the mylo-hyoid ridge of the mandible; (3) the outer surface of the alveolar process of the mandible below the molar teeth.

Insertion.—The outer part of the orbicularis oris.

Structure.—It rises by fleshy fibres which run forwards in four sets. The upper set pass directly into the facial portion of the orbicularis oris which belongs to the upper lip; the next pass downwards and forwards to that which belongs to the lower lip; the third upwards and forwards, decussating with the second set to join the lower part of the orbicularis in the upper lip. Finally, a fourth set which pass from the mandible to the lower part of the facial portion of the orbicularis oris belonging to the lower lip.

Nerve-supply.—The buccal branch of the lower division of the facial, which sends filaments into the back part of its outer surface; it is also pierced by the buccal branch of the inferior maxillary division of the fifth nerve on its way to supply the mucous membrane lining the cheek.

Action.—(1) To draw outwards the corner of the mouth, widening it and pressing the lips against the teeth; (2) to diminish the concavity of the cheek, compressing the air contained in it, as in using the blowpipe or playing the cornet; or forcing inwards the food when, in mastication, any portion of it has escaped into that part of the mouth which is external to the bicuspids and molar teeth.

Relations.—Superficially, the skin, subcutaneous fat, Stenson's duct, the zygomaticus major, risorius, a large mass of fat (**the buccal fat-pad**) which separates the buccinator from the masseter, and a layer of deep fascia continuous with that which covers the upper part of the pharynx; deeply, the mucous membrane of the mouth. The upper part of the muscle is perforated by Stenson's duct. The buccinator is almost continuous behind with the superior constrictor, from which it is only separated by the tendinous intersection of the pterygo-maxillary ligament.

ANGULAR MUSCLES OF THE MOUTH

The angular series are four in number: viz. the zygomaticus major, levator anguli oris, risorius, and depressor anguli oris. Two descend to the corner of the mouth obliquely from above, one runs almost horizontally forwards, and one ascends from below. They blend at the corner of the mouth, and form there a thick muscular mass, behind which is a depression filled up with the fat covering the buccinator. In a lean face this depression is often very conspicuous, and in some faces its position is indicated by a dimple when the zygomaticus major contracts.

1. ZYGOMATICUS MAJOR

The **zygomaticus major**—named from its origin from the zygoma and its size—is ribbon-shaped, and belongs to the first layer of the muscles.

Origin.—The outer surface of the malar bone near the zygomatic suture.

Insertion.—The deep surface of the skin, and the subcutaneous tissue at the outer extremity of the upper lip, and just external to the commissure of the lips.

Structure.—Arising by short tendinous fibres, the muscle forms a fleshy band which passes downwards and forwards to the meeting-point of the angular muscles at and external to the angle of the mouth, where it blends with the orbicularis oris and the other angular muscles, its outermost fibres passing into the outer fibres of the depressor anguli oris.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve, which enters the middle of its deep surface.

Action.—To draw upwards and outwards the corners of the mouth, as in smiling or laughter. When it is strongly contracted, it throws into prominence the soft parts of the cheek in front of the malar bone, raises the lower eyelid, and produces 'crow's feet,' as the wrinkles are called which radiate outwards from the outer canthus. When both muscles act together, the mouth is widened, and the upper lip raised so as to show the upper teeth, in what is called a 'broad grin.'

Relations.—Superficially, the skin; deeply, the buccinator and facial part of the orbicularis oris, the facial and transverse facial arteries, the facial vein, and some branches of the facial nerve.

2. LEVATOR ANGULI ORIS

The **levator anguli oris**—named from its action upon the corner of the mouth—is a triangular sheet and belongs to the second stratum of the facial muscles.

Origin.—The canine fossa of the maxilla.

Insertion.—The deep surface of the skin, and the subcutaneous tissue, close to the corner of the mouth.

Structure.—Arising muscular from its broad origin above the canine and bicuspid teeth, the fibres converge in a downward and outward direction, and blend with the other angular muscles outside the corner of the mouth.

Nerve-supply.—The infraorbital branch of the upper division of the facial at the outer part of the anterior surface.

Action.—To raise the corner of the mouth, but at the same time to draw it inwards.

Relations.—Superficially, the zygomaticus minor and levator labii superioris, the infraorbital vessels and nerves; deeply, the facial portion of the orbicularis oris.

3. RISORIUS

The **risorius**—named from its supposed action in laughter—is flat and ribbon-shaped, and belongs to the superficial layer of muscles, being a part of the platysma myoides, and often very small and ill-developed.

Origin.—The subcutaneous tissue overlying the deep fascia which covers the masseter and parotid gland.

Insertion.—The subcutaneous and muscular tissue external to the angle of the mouth.

Structure.—It is a band of parallel fibres which runs transversely forwards from the upper and posterior part of the platysma to the corner of the mouth.

Nerve-supply.—The buccal branch of the lower division of the facial nerve which enters it from beneath.

Action.—To widen the mouth by drawing its corner directly outwards. It is not used in the expression of pleasure like the zygomaticus major, but it gives a strained painful expression to the features, such as is seen in tetanus, and called the 'risus sardonicus.'

Relations.—Superficially, the skin and subcutaneous fat; deeply, the masseter and buccinator, the facial artery and vein, and branches of the facial nerve.

4. DEPRESSOR ANGULI ORIS

The **depressor anguli oris**—named from its action upon the corner of the mouth—is a triangular sheet, and belongs to the superficial layer of facial muscles.

Origin.—The outer aspect of the lower border of the body of the mandible and the external oblique line below the canine, bicuspid, and first molar teeth.

Insertion.—The subcutaneous connective tissue, and the muscular mass external to the corner of the mouth.

Structure.—Its fibres, arising fleshy, converge upwards and inwards, and, having diminished to a narrow band, join the general muscular mass at the corner of the mouth, some of them being continued upwards into the levator anguli oris, and the most external into the zygomaticus major.

The fibres which form the inner border of the muscle are often continued downwards below the mandible, and form with those of the other side a band, partly muscular and partly fibrous, which, lying beneath the platysma myoides, supports and compresses the subcutaneous fat below and behind the prominence of the chin. When there is much subcutaneous fat, the absence of this support gives rise to a considerable prominence behind this band, producing the so-called 'double chin.'

Nerve-supply.—The supramandibular branch of the lower division of the facial nerve, which sends filaments to the back part of its deep surface.

Action.—To draw downwards and somewhat outwards the angle of the mouth, giving an expression of sorrow to the face, and making the individual look 'down in the mouth.'

Relations.—The skin superficially; and deeply, the depressor labii inferioris and inferior coronary artery.

Labial Group of Muscles

The **labial group** consists of three muscles which pass downwards from the maxilla, and form a continuous sheet which might fairly be included under one name; and a fourth muscle which passes upwards from the mandible. All the muscles are inserted into the lips, and especially into that part of them which intervenes between the middle line and a point half way between this and the corner of the mouth.

The upper set is formed by the levator labii superioris alæque nasi, the levator labii superioris, and the zygomaticus minor; the lower muscle is the depressor labii inferioris.

1. LEVATOR LABII SUPERIORIS ALÆQUE NASI

The **levator labii superioris alæque nasi**—named from its action as an elevator of the upper lip and the nostril—is a somewhat triangular sheet, bifurcating below at the base which corresponds to the insertion of the muscle. It belongs to the superficial layer of facial muscles.

Origin.—The anterior half of the outer surface of the nasal process of the maxilla.

Insertion.—(1) The deep surface of the skin which covers the lower part of the ala nasi; (2) the deep surface of the skin and the general muscular mass, of the inner half of the upper lip.

Structure.—Arising fleshy, its fibres diverge somewhat as they pass downwards; they then decussate with those of the orbicularis oris close to the prolabium.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve, which sends filaments to the outer part of the deep surface of the muscle.

Action.—(1) To raise and dilate the nostril; (2) to raise the inner half of the upper lip.

Relations.—Superficially, the skin and orbicularis palpebrarum; deeply, the compressor narium and levator anguli oris.

2. LEVATOR LABII SUPERIORIS

The **levator labii superioris**—named from its action—is a nearly square sheet, and it belongs to the superficial layer of muscles.

Origin.—The front of the maxilla just below the margin of the orbit, and from the adjacent part of the malar bone.

Insertion.—The deep surface of the skin and the subjacent muscular tissue near the upper edge of the inner half of the upper prolabium.

Structure.—Its fibres, arising fleshy, descend parallel to one another and almost vertically to their insertion, where they interlace with the fibres of the orbicularis oris. It frequently receives at its outer border some bundles of fibres from the orbicularis palpebrarum.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve, which sends filaments to the outer part of its deep surface.

Action.—To raise the inner half of the upper lip. This muscle, with its two fellows, the preceding and following, is especially used in the expression of grief, and to some extent of anger also, as when the lip is raised and somewhat everted so as to show the canine tooth. In crying, the action of these muscles is strongly displayed, for when the eyes are closed by the orbiculares palpebrarum, at the same time the mouth is made square by the elevation of the inner half of the lip, while the outer half is drawn down by the depressor anguli oris.

Relations.—Superficially, the skin and orbicularis palpebrarum; deeply, the levator anguli oris, the infraorbital vessels and nerve.

3. ZYGOMATICUS MINOR

The **zygomaticus minor**—named from its association with the zygomaticus major and its smaller size—is a small ribbon-shaped band, often absent, and belonging to the superficial layer of facial muscles.

Origin.—The lower part of the front of the malar bone close to its junction with the maxilla.

Insertion.—The deep surface of the skin and the subjacent muscular tissue at a point upon the upper border of the prolabium of the upper lip about midway between the middle line and the outer corner of the mouth.

Structure.—Arising fleshy, the small band of parallel fibres which is upon its inner margin closely connected with the preceding muscle, passes downwards and inwards to its insertion, which interlaces with the fibres of the orbicularis oris.

Nerve-supply.—The infraorbital branch of the upper division of the facial nerve, which sends filaments to the deep surface of the muscle.

Action.—To raise and somewhat evert the part of the upper lip to which it is attached.

Relations.—Superficially, the skin and orbicularis palpebrarum; deeply, the levator anguli oris, facial portion of the orbicularis oris, and the infraorbital branch of the facial nerve.

4. DEPRESSOR LABII INFERIORIS

The **depressor labii inferioris**, or **quadratus menti**—named from its action, or shape, and its connection with the lower lip and chin (*mentum*)—is a nearly square sheet, and belongs to the second layer of the facial muscles.

Origin.—The outer aspect of the lower border of the body of the mandible below the canine and bicuspid teeth.

Insertion.—The deep surface of the skin and the subjacent muscular mass along the lower edge of the prolabium of the lower lip.

Structure.—It consists of parallel muscular fibres, many of them continuous with those of the platysma myoides, which pass upwards and inwards to interlace with the fibres of the orbicularis oris along the line above mentioned. The inner margins of the muscles of the two sides meet above in the middle line.

Nerve-supply.—The supramandibular branch of the lower division of the facial nerve, which sends filaments to its deep surface near its outer border.

Action.—To draw down and somewhat evert the lower lip.

Relations.—Superficially, the skin and the depressor anguli oris; deeply, the facial portion of the orbicularis oris, the mental vessels, and nerve.

Muscles radiating from the Mouth

The two muscles which radiate from the mouth are the depressor alæ nasi and the levator menti.

1. DEPRESSOR ALÆ NASI

The depressor alæ nasi has been described with the muscles of the nose.

2. LEVATOR MENTI

The **levator menti,** or **levator labii inferioris**—named from its action—is a short, thick, and somewhat fan-shaped muscle, belonging to the second layer.

Origin.—The incisive fossa of the mandible, below and a little internal to the attachment of the incisivus inferior of the orbicularis oris.

Insertion.—The subcutaneous tissue just above the point of the chin.

Structure.—Arising fleshy, its fibres diverge slightly as they pass downwards and inwards to meet in the middle line with those of the opposite side just below a pellet of fat which lies beneath the skin at a short distance above the point of the chin.

Nerve-supply.—The supramandibular branch of the lower division of the facial nerve, which terminates in this muscle.

Action.—To draw upwards the skin covering the prominence of the chin, and to elevate and shoot out the lower lip. It has been sometimes called the *musculus superbus*, from the haughty and contemptuous expression which it produces when it acts at the same time with the depressor anguli oris. A slighter contraction, however, gives the mouth an expression of firmness and decision.

Relations.—Superficially, the mucous membrane of the mouth and the facial portion of the orbicularis oris above, the subcutaneous fat below; deeply, the mandible.

MUSCLES OF MASTICATION

The **muscles of mastication** form an independent group, four in number, occupying the back part of the side of the face, and the temporal and zygomatic fossæ, and consisting of the masseter, the temporal, with the external and internal pterygoid muscles. The temporal muscle is covered by a strong membrane, the **temporal fascia,** which, arising from the temporal ridge, is attached below to the upper border of the zygoma, after first dividing into two laminæ which go to the outer and inner aspects of this border, and contain between them a small quantity of fat. From the zygoma downwards, the **masseteric fascia** is continued to the posterior and inferior borders of the ramus of the mandible, enveloping the masseter muscle. Closely connected with this is the **parotid fascia** which envelops the parotid gland, extending backwards from the masseteric fascia to that part of the deep cervical fascia which covers the upper portion of the sterno-mastoid muscle; covering also the deep surface of the gland, and giving off a process called the *stylo-maxillary* ligament, which, running from the styloid process to the angle of the mandible, separates the parotid and submaxillary glands.

1. MASSETER

The **masseter** (fig. 311)—named from the Greek word *μασάομαι*, to chew—is a strong quadrate sheet, consisting of two layers.

Origin.—The *superficial layer*, from the lower border of the malar bone, and the lower border of the anterior two-thirds of the zygomatic arch; the *deep layer*, from the lower border of the posterior third of the zygomatic arch, and the whole of its inner surface.

Insertion.—The *superficial layer*, into the lower half of the outer surface of the ramus of the mandible; the *deep layer*, partly with the superficial layer, and partly into the upper half of the outer surface of the ramus of the mandible.

Structure.—The origin and insertion are by tendinous bands intermingled in multipenniform fashion with fleshy fibres. The fibres of the superficial sheet are directed obliquely downwards and backwards; those of the deep sheet almost vertically downwards, and they are much shorter than the superficial fibres. The two sheets blend closely in front, but are separate behind, where the muscle forms a sort of pocket closed above at the origin and below at the insertion, as well as in front, but open behind.

Nerve-supply.—The masseteric branch of the motor portion of the mandibular division of the fifth nerve, which enters the deep surface of the muscle just below the zygoma.

Action.—To close the jaw, and by its superficial layer to draw it slightly forwards. In closing the jaw it acts with less mechanical disadvantage than is usual with muscles. When the pressure to be overcome is exerted upon the back teeth, the arm of the lever upon which the power acts is almost as long as that which intervenes between these teeth and the fulcrum. This fulcrum is not at the temporo-mandibular joint, but at a point below the neck of the mandible, corresponding very nearly to the lower attachment of the internal lateral ligament. Moreover, the resultant force of the muscle, acting as it does upwards and forwards, is perpendicular to the lever, which may be roughly described as a bar extending downwards and forwards from the neck of the mandible to the point of the chin.

Relations.—Superficially, the parotid gland and its duct, the platysma myoides, the risorius and the masseteric fascia, the transverse facial vessels, the facial vein, the upper and lower divisions of the facial nerve; deeply, the buccal fat-pad which separates it from the buccinator and a small part of the temporal muscle.

2. THE TEMPORAL MUSCLE

The **temporal muscle**—named from its attachment to the temple (= *tempus*) —is a thick, somewhat triangular sheet; more correctly it may be described as forming the quadrant of a circle.

Origin.—(1) The whole of the temporal fossa, from the temporal to the pterygoid ridge, with the exception of a small part close to the outer wall of the orbit, which is occupied by fat; (2) the inner surface of the temporal fascia down to its lower attachment to the zygomatic process, from the inner surface of which some of its fibres also sometimes arise.

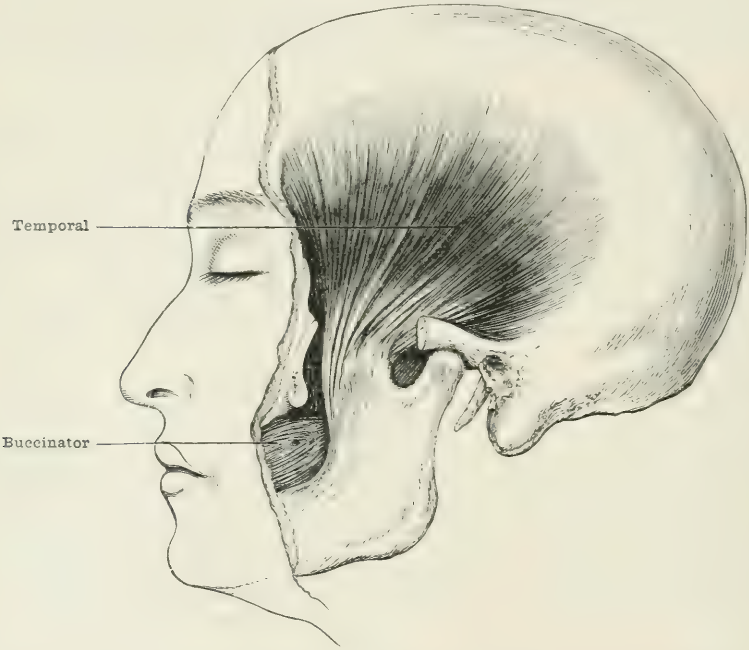
Insertion.—The point, posterior border, and the whole of the inner surface of the coronoid process of the mandible, down to the last molar tooth.

Structure.—The bones of the temporal fossa and the temporal fascia form a pouch, open downwards, from which the fleshy fibres of the muscle converge, the middle fibres running downwards, the anterior downwards and backwards, the posterior almost transversely forwards, to be inserted below upon both faces of a flat tendon which, becoming free of flesh on the outer surface first, embraces the point and borders of the coronoid process.

Nerve-supply.—The two or three deep temporal branches of the motor portion of the mandibular division of the fifth nerve, which enter the lower part of its deep surface.

Action.—To close the jaw: its posterior fibres will also draw it backwards after the other muscles have protruded it. This muscle, like the masseter, has to contend with very little mechanical disadvantage, power being of more importance in mastication than speed.

FIG. 312.—THE TEMPORAL MUSCLE.



Relations.—Superficially, the temporal fascia which separates it from some of the auricular muscles, the sides of the epicranial aponeurosis, the auriculo-temporal nerve, and the upper branches of the facial nerve; the zygoma and a small part of the masseter. Deeply, the temporal fossa, and the external pterygoid muscle.

At its posterior border it is crossed by the masseteric nerve and vessels.

3. PTERYGOIDEUS EXTERNUS

The **pterygoideus externus**—named from its attachment to the pterygoid process of the sphenoid bone, and its relation to the companion muscle—consists of two thick triangular sheets, the one lying in a horizontal, and the other in a vertical plane.

Origin.—**Upper head**: the under surface of the great wing of the sphenoid bone, internal to the pterygoid ridge, and external to the foramen ovale and foramen spinosum. **Lower head**: All the outer surface of the external pterygoid plate.

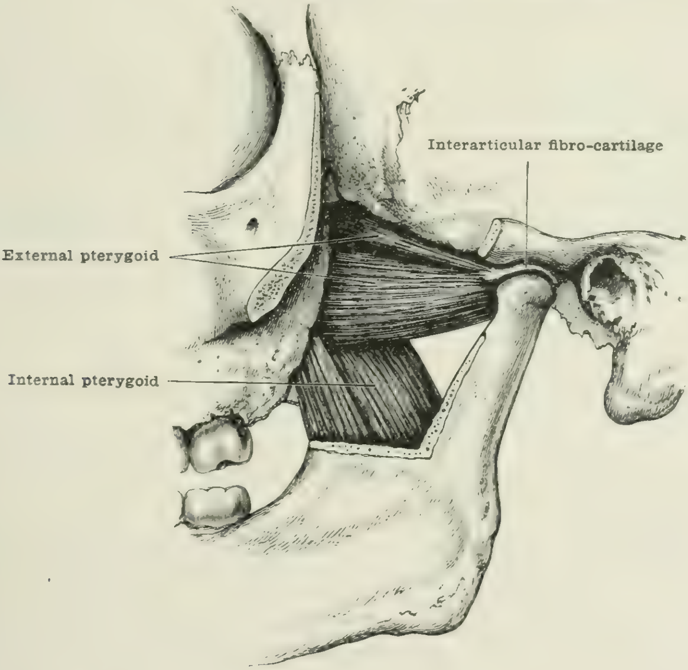
Insertion.—**Upper head**: (1) The front of the interarticular fibro-cartilage of the temporo-mandibular joint; (2) the adjacent portion of the capsular ligament; (3) the upper part of the front of the neck of the condyle of the mandible. **Lower head**: The pit in the front of the neck of the condyle.

Structure.—Arising by fleshy fibres, which are closely connected at the pterygoid ridge with part of the temporal muscle, the upper head forms a fan-shaped sheet and passes backwards and slightly outwards to its insertion, which is by short tendinous fibres blending below with those of the lower head. The lower and much stronger head is at first separated from the upper by a small chink, which may give passage to the internal maxillary vessels. It arises fleshy, converges backwards, outwards, and somewhat upwards, and is inserted by short tendinous fibres.

Nerve-supply.—The external pterygoid branch of the motor portion of the mandibular division of the fifth nerve, which divides into filaments entering its deep surface.

Action.—(1) To draw forwards the ramus of the mandible, and the interarticular fibro-cartilage; (2) to draw them inwards. The combination of these two movements produces the oblique movement of the lower molar teeth of one side forwards and inwards with respect to the upper molars which are their opponents. It should be observed also that this inward movement of one side is the action by which the ramus of the opposite side is moved outwards. (3) To assist in opening the mouth by depression of the lower jaw. As the transverse axis of this movement passes through the mandible at two points situated below the necks of the rami, it follows that a forward movement of the condyles and necks will assist in the backward movement of the angles and body which accompanies the depression of the mandible.

FIG. 313.—THE PTERYGOID MUSCLES.



Relations.—Superficially, the anterior fibres of the internal pterygoid, the temporal muscle, and, at a little distance, a small part of the masseter; deeply, the internal pterygoid muscle, the internal maxillary vessels (unless, as sometimes, they pass across the outer surface of the lower head), the middle meningeal and inferior dental vessels, with the masseteric and posterior deep temporal nerves passing behind or through the attachment of the upper head; the buccal and anterior deep temporal nerves running between the two heads; the lingual gustatory and inferior dental nerves beneath the lower head.

Variations.—Muscular fibres are frequently found upon the deep surface of the external pterygoid, running from the back of the external pterygoid plate to the spine of the sphenoid, or the vaginal process of the temporal bone.

4. PTERYGOIDEUS INTERNUS

The **pterygoideus internus**—named from its origin and relative position—is a thick quadrilateral sheet.

Origin.—(1) The whole of the inner surface of the external pterygoid plate and the adjacent part of the tuberosity of the palate bone. (2) A small triangular area, consisting of the outer surface of the tuberosity of the palate bone, and a small strip in front belonging to the maxilla.

Insertion.—The lower half of the internal surface of the ramus of the mandible, including the adjacent parts of its lower and posterior borders, and extending as high as the mylo-hyoid ridge and inferior dental canal.

Structure.—Arising fleshy, the fibres run parallel to one another, downwards, backwards, and outwards, to be inserted partly into the mandible, and partly in multipenniform fashion, like those of the masseter, into the tips and sides of fibrous septa, which, passing upwards from the periosteum of the mandible, separate the muscular bundles from one another.

Nerve-supply.—The internal pterygoid branch of the motor portion of the mandibular division of the fifth nerve, which enters the deep surface near its posterior border.

Action.—(1) To close the jaw. The same remarks which were made with respect to the very small loss of mechanical advantage in the masseter muscle apply to this muscle. (2) When closed it will draw the jaw forwards; and also (3) it will help the external pterygoid in drawing the ramus of its own side towards the middle line.

Relations.—Superficially, the external pterygoid muscle, the internal lateral ligament, the internal maxillary vessels, the inferior dental and lingual nerves; deeply, the tensor palati and superior constrictor of the pharynx, the stylo-hyoid muscle and the posterior belly of the digastric, the submaxillary gland.

THE MUSCLES AND FASCIÆ OF THE FRONT OF THE NECK

The **platysma myoides** has been already described (page 426) with the muscles of expression.

The muscles of the neck which lie beneath it are surrounded by a layer of deep fascia, called the **cervical fascia.** This is a strong tubular membrane, attached above to the lower border of the mandible, the parotid fascia, the upper part of the mastoid process, and the superior nuchal line. At the back of the neck it is continuous with the deep fascia which gives a thin investment to the trapezius muscle. In front, it is attached to the lower border of the body and great cornu of the hyoid bone. Below, it ends upon the front surface of the presternum and the clavicle. The *deep layer* of the cervical fascia separates from it just below the hyoid bone, and runs downwards in close proximity to the sterno-hyoid muscles and the other depressors of the hyoid bone, to the upper part of the posterior surface of the sternum, and the posterior surface of the clavicle. Laterally, it blends with and completes the sheath of the sterno-mastoid muscle, which is partly formed by the superficial layer of the cervical fascia; it also binds down the posterior belly of the omo-hyoid to the clavicle and first rib. Below its attachment to the sternum and clavicle it is continued downwards in front of the trachea and great vessels at the root of the neck into the superior mediastinum, and it finally joins the pericardium. Behind, it gives an investment to the depressors of the hyoid bone. Between this deep layer of the cervical fascia and the superficial layer is a small space containing a part of the course of the anterior jugular vein, a lymphatic gland, some fat and loose connective tissue.

A still deeper fibrous layer, the **prevertebral fascia,** stretches across the neck and divides the cylindrical tube formed by the cervical fascia into a posterior and anterior compartment. Its surfaces are directed forwards and backwards. Behind, it rests in the middle line upon the ligaments covering the front of the bodies of the cervical vertebræ. Laterally, it covers in the prevertebral muscles, and is attached to the deep surface of the *superficial layer* of the cervical fascia between the sterno-mastoid and trapezius muscles.

In the compartment formed between the deep layer of the cervical fascia as it invests the depressors of the hyoid bone, and the prevertebral fascia, processes are given off which form the sheath of the great vessels of the neck, and invest the thyroid gland, the trachea, and pharynx.

The muscles of the front of the neck may be divided into three groups: the first group consisting of one muscle which ascends from the sternum and clavicle to the head, the sterno-cleido-mastoideus; the second, of those which ascend from the sternum, clavicle, and shoulder-blade to the hyoid bone and thyroid cartilage; the third, of those which are attached to the hyoid bone below, and the skull and lower jaw above.

First Group

STERNO-CLEIDO-MASTOID

The **sterno-cleido-mastoid,** or **sterno-mastoid muscle**—named from its attachments (*κλείς* = a key, being the equivalent of clavicle)—is a strong ribbon-shaped band, bifurcated below, and somewhat constricted in its middle third.

Origin.—Sternal head: the front of the manubrium (or presternum) between the notches, the middle line, and for the clavicle and first rib. **Clavicular head:** The upper part of the anterior surface of the inner third of the clavicle.

Insertion.—(1) Along the anterior border and the outer surface of the mastoid process of the temporal bone; (2) the outer half of the superior nuchal line of the occipital bone.

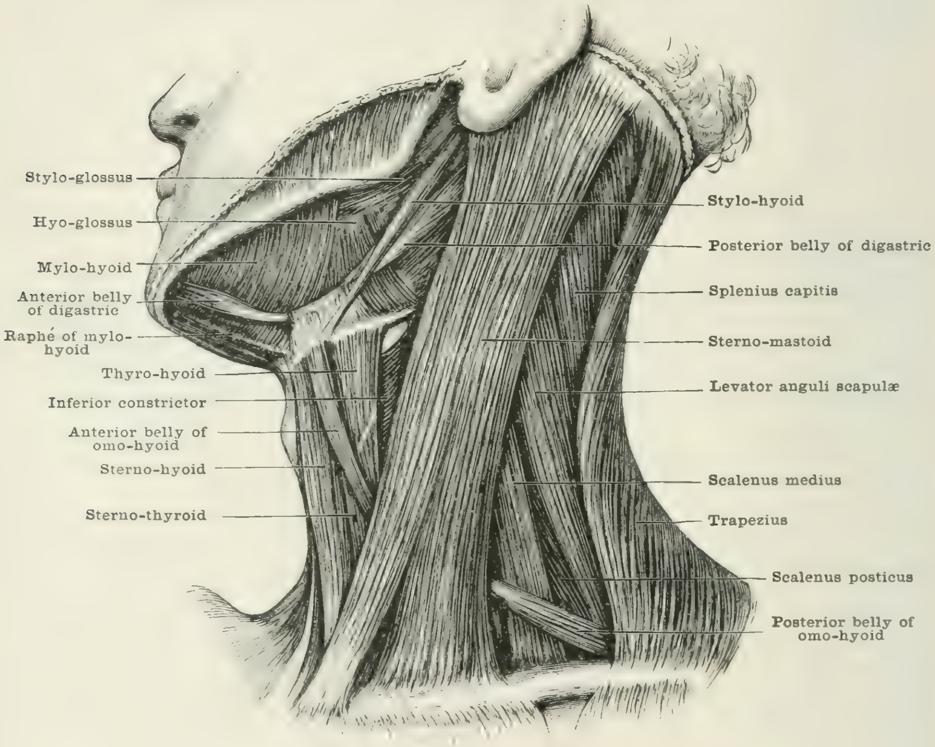
Structure.—The sternal head is a rounded but flat tendon; the clavicular is partly fleshy and partly tendinous. After a course of about an inch (2·5 cm.), the sternal head expands into a flat muscle, which conceals the greater part of the clavicular portion, and, passing upwards, outwards, and backwards, is spread over the whole line of the upper attachment. Frequently it is so separate from the clavicular head, that they might very fairly be considered to form two muscles. The clavicular head soon becomes entirely fleshy and ascends more directly. At first it is separated by a small interval from the sternal head, corresponding to a part of the sterno-clavicular joint, from which it sometimes receives a few fibres of origin; when they have joined, it passes beneath the sternal head to its insertion, which is chiefly the lower part of the outer surface of the mastoid process. The whole insertion in front is composed of short tendinous fibres, and behind of a thin aponeurosis. As the whole muscle has a very wide range of action, nearly the whole length of its fibres is fleshy. The sternal head is a little longer than the other, but has little if any more range of movement. Hence it is tendinous.

Nerve-supply.—(1) The spinal accessory nerve, which, while traversing the deep surface of the muscle at the junction of its upper and middle thirds, sends filaments to it; (2) the cervical plexus through the anterior primary branches of the second and third cervical nerves, which enter the upper part of its deep surface.

Action.—(1) To flex laterally the head and neck, so as to draw the side of the head towards the shoulder. (2) To rotate the face towards the opposite side. Of the two parts of the muscle, the cleido-mastoid portion is more concerned in lateral flexion, the sterno-mastoid in rotation. The combination of all these movements may be very well seen in a case of wry-neck, which results from the permanent contraction of this muscle. (3) When both muscles act, to flex the head and neck upon the thorax, at the same time raising slightly the chin, which is therefore carried horizontally forwards. (4) To raise the sternum and inner end of the clavicle. This action may sometimes be seen in patients with paralysis of all the parts beneath the cervical region, when the only nerves available for respiratory movements are the phrenic and those which supply certain of the muscles of the neck. (5) If the head be much thrown back, the two sterno-mastoids may be used to increase the extension.

Relations.—Superficially, the deep cervical fascia and integuments, the platysma myoides, external jugular vein, and many of the superficial branches of the cervical plexus, and the glandulæ concatenatæ; deeply, the rectus capitis anticus major, omo-hyoid, sterno-hyoid and sterno-thyroid, the posterior belly of the digastric, the splenius capitis, levator anguli scapulæ, and three scalene muscles; the common, external, and internal carotid and subclavian arteries, with several branches of the external carotid, the internal jugular, facial, thyroid, anterior jugular, and other veins; the spinal accessory and hypoglossal nerves, the cervical and upper part of the brachial plexuses with many of their branches, the parotid gland, the lateral lobe of the thyroid gland, and numerous deep cervical lymphatic glands.

FIG. 314.—ANTERIOR AND LATERAL CERVICAL MUSCLES.


Stylo-glossus
Hyo-glossus
Mylo-hyoid
Anterior belly of digastric
Raphé of mylo-hyoid
Thyro-hyoid
Inferior constrictor
Anterior belly of omo-hyoid
Sterno-hyoid
Sterno-thyroid
Stylo-hyoid
Posterior belly of digastric
Splenius capitis
Sterno-mastoid
Levator anguli scapulæ
Scalenus medius
Trapezius
Scalenus posticus
Posterior belly of omo-hyoid

Variations.—The clavicular origin may extend farther outwards upon the collar bone. Besides its insertion into the mastoid process, this head may have an attachment to the superior nuchal line, called the *cleido-occipital*. An extension of the sternal head has been observed arising from the costal cartilages as low as that of the fifth rib. Slips sometimes pass from the upper part of the muscle to the angle of the jaw, the pharynx, the auricle, or the upper attachment of the trapezius.

THE INFRA-HYOID MUSCLES

The infra-hyoid muscles form a group of four long flat muscles, arranged in two layers, and enveloped by the deep layer of the cervical fascia.

Superficial Layer

This consists of two muscles—the sterno-hyoid and omo-hyoid.

1. STERNO-HYOID

The **sterno-hyoid** (figs. 301 and 314)—named from its two attachments—is long and ribbon-shaped.

Origin.—(1) The back of the manubrium (presternum) just internal to the notches for the clavicle and first rib; (2) the back of the posterior sterno-clavicular ligament; (3) the back of the inner end of the clavicle external to the facet for the first costal cartilage.

Insertion.—The lower border of the body of the hyoid bone, close to the middle line.

Structure.—It arises fleshy, and forms a band of parallel fibres, which approach the middle line as they ascend, and are inserted by a short tendon.

Nerve-supply.—From the first three cervical nerves through the descendens and communicantes hypoglossi, which send filaments to its deep surface near its upper end.

Action.—To draw down the body of the hyoid bone, e.g. after it has been raised in swallowing; also to fix it when the muscles which pass upwards from it are depressing the tongue, as in suction.

Relations.—Superficially, the deep cervical fascia, sterno-mastoid, sterno-clavicular joint, anterior jugular vein; deeply, the sterno-thyroid, crico-thyroid, thyroid and cricoid cartilages, the trachea, thyroid isthmus, and the inferior thyroid vein.

Variations.—The sterno-hyoid may arise from the clavicle alone, and occasionally even from the middle of that bone. It may be absent or double. A tendinous intersection sometimes crosses it.

2. OMO-HYOID

The **omo-hyoid** (ὦμος = shoulder)—named from its attachment to the shoulder-blade and the hyoid bone—is ribbon-shaped with a tendinous constriction in the middle which divides it into two fleshy bellies.

Origin.—(1) The upper border of the scapula for about an inch (2·5 cm.) behind the suprascapular notch; (2) occasionally, the upper border of the transverse ligament which crosses the notch.

Insertion.—The lower border of the body of the hyoid bone just external to the preceding muscle, which it also slightly overlaps.

Structure.—Arising fleshy and broad, the muscle contracts slightly as it passes forwards, and a little upwards, across the posterior triangle of the neck above the clavicle. Beneath the sterno-mastoid, and over the great vessels of the neck, it becomes tendinous for a short distance; and then, changing its direction, it again expands to a fleshy band which runs upwards and slightly forwards and inwards to its insertion, which is by short tendinous, intermingled with fleshy, fibres. An obtuse angle is formed between the two bellies, the lower portion of the muscle and its tendon being held down by a strong process of the deep layer of the cervical fascia, which, forming a loop around them, passes downwards to be attached to the posterior surface of the clavicle and to the first rib.

Nerve-supply.—The anterior belly is supplied by a branch from the descendens hypoglossi, which enters the back of its deep surface, while the posterior receives a branch from the loop of communication between this nerve and the communicantes hypoglossi which enters the deep surface of the muscle close to its junction with the tendon.

Action.—(1) To draw down the hyoid bone; (2) very slightly to help in raising the scapula; (3) to make tense the lower part of the cervical fascia. In this way it assists the platysma myoides in diminishing the inward suction of the soft parts, which tends to compress the great vessels and the apices of the lungs during prolonged inspiratory efforts. The part of the muscle between the sterno-mastoid and the carotid sheath, being tendinous, will not vary in thickness, otherwise during contraction it might tend to obstruct the vessels beneath.

Relations.—Superficially, the deep cervical fascia, sterno-mastoid, clavicle, subclavius and trapezius, the external jugular vein, and the descending branches of the superficial cervical plexus; deeply, the thyro-hyoid, sterno-thyroid, scaleni, and the first digitation of the serratus magnus, the sheath of the common carotid artery and internal jugular vein, the upper part of the brachial plexus, often the third part of the subclavian artery with the transversalis colli and suprascapular vessels and the suprascapular nerve.

Variations.—These are very frequent. It may be absent or double. The posterior belly may be attached to the clavicle and scapula, or to the clavicle alone. It may receive a slip from the manubrium. The anterior belly may blend with the sterno-hyoid, and it may send a slip to the thyroid cartilage or the mandible.

SECOND LAYER OF INFRA-HYOID MUSCLES

This consists of two muscles—the sterno-thyroid and thyro-hyoid.

1. STERNO-THYROID

The **sterno-thyroid** (figs. 301 and 314)—named from its attachment to the sternum and thyroid cartilages—is flat and ribbon-shaped.

Origin.—(1) The lower part and side of the back of the manubrium (presternum), from the middle line to the notch for the first rib cartilage; (2) the back of the first rib cartilage, and occasionally that of the second; and (3) occasionally from the back of the clavicle near the facet for the first costal cartilage.

Insertion.—The oblique line on the outer surface of the ala of the thyroid cartilage.

Structure.—Arising fleshy, the two muscles form broad bands of parallel fibres, which at first lie close to one another, and afterwards diverge slightly as they ascend. Finally, they are inserted by short tendinous fibres into the thyroid cartilage. Occasionally, the muscle is crossed by a tendinous intersection.

Nerve-supply.—Branches from the loop between the descendens and the communicantes hypoglossi which enter the outer part of the deep surface of the muscle.

Action.—(1) To draw down the thyroid cartilage, e.g. after swallowing; (2) in conjunction with the thyro-hyoid it will depress the hyoid bone.

Relations.—Superficially, the cervical fascia, the anterior jugular vein, the sterno-mastoid and sterno-hyoid and omo-hyoid muscles; deeply, the inferior constrictor, the cricoid cartilage, crico-thyroid muscle, thyroid gland, inferior thyroid veins and trachea, the common carotid artery and left innominate vein.

Variations.—This muscle may be absent or double; the muscles of the two sides may be united. It may send a slip to the carotid sheath.

2. THYRO-HYOID

The **thyro-hyoid**—named from its attachment to the thyroid cartilage and hyoid bone—is a quadrilateral sheet.

Origin.—The oblique line on the outer surface of the ala of the thyroid cartilage.

Insertion.—The lower border of (1) the outer third of the body of the hyoid bone; and of (2) the inner half of the greater cornu.

Structure.—This muscle is a continuation upwards of the preceding muscle, many of its fibres being derived from those of the sterno-thyroid without any attachment to the cartilage. It consists of parallel fleshy fibres which run nearly vertically upwards to their insertion into the hyoid bone.

Nerve-supply.—A special branch of the hypoglossal nerve which enters the deep surface of the muscle near its posterior border.

Action.—(1) To draw up the thyroid cartilage, as in swallowing, or in the production of a high note in singing; (2) in association with the sterno-thyroid to draw down the hyoid bone.

Relations.—Superficially, the sterno-hyoid, omo-hyoid, and sterno-mastoid; deeply, the thyro-hyoid membrane, the thyro-hyoid bursa, the superior laryngeal vessels and nerve.

Variations.—Slips are occasionally seen passing from the cricoid cartilage to the hyoid bone, or between the upper border of the thyroid cartilage in front and the body of the hyoid bone.

THE SUPRA-HYOID MUSCLES

These consist of four muscles arranged in three layers: the first containing the digastric and stylo-hyoid, the second the mylo-hyoid, and the third the genio-hyoid.

1. DIGASTRIC

The **digastric**—named from its two bellies (*γαστήρ*, the belly)—is composed of two flattened and somewhat spindle-shaped bellies united by a tendon.

Origin.—(1) Of *posterior belly*, the digastric fossa of the temporal bone: (2) of *anterior belly*, the lower border of the body of the mandible just external to the symphysis.

Insertion.—By its central tendon, which is attached to the outer part of the lower border of the body of the hyoid bone and the adjacent part of the great cornu.

Structure.—The *posterior belly* at its origin consists of short tendinous fibres, which soon form a laterally compressed muscle. This passes downwards, forwards and inwards, and converges upon a laterally flattened rounded tendon about half an inch (1·2 cm.) above the tip of the great cornu of the hyoid bone.

The *anterior belly* arises by short tendinous fibres, and forms a muscle flattened from before backwards and from above downwards, which is shorter and smaller than the posterior belly. Its fibres converge as they pass backwards and slightly downwards and outwards, to end in the flattened tendon a quarter of an inch (6 mm.) above the junction of the body and great cornu of the hyoid bone. The central tendon is bound down to its insertion upon the hyoid bone, chiefly by a fibrous expansion given off from its lower border, and to a very small degree also by the oblique arch over it formed by the division of the stylo-hyoid muscle. Often, a part of this expansion passes inwards across the middle line and, uniting with its fellow, forms a membranous covering to the deeper structures, and unites the inner borders of the two anterior bellies.

Nerve-supply.—The posterior belly, which is really a distinct muscle, belonging to a deeper stratum of the muscular planes, receives a special branch from the facial nerve which enters the upper part of its deep surface. Perhaps this may be due to the fact that this part of the muscle assists in swallowing: for the facial nerve, by means of the Vidian and the relations which through the lesser superficial petrosal nerve it has with the otic ganglion, may be considered to take part in this function, as well as in the expression of emotions.

The anterior belly receives at the outer part of its deep surface the terminal filaments of the mylo-hyoid twig from the inferior dental (or mandibular) branch of the mandibular division of the fifth nerve.

Action.—(1) The posterior belly draws upwards and backwards the hyoid bone, as in the elevation of the larynx in the second part of deglutition; (2) the anterior belly, acting from above, draws upwards and forwards the hyoid bone; and, acting in the opposite direction, (3) it assists in the depression of the lower jaw and in opening the mouth. Although a comparatively weak muscle, it acts with considerable power in this movement, for it is inserted at the end of the lever of the second order formed by the mandible, while the resistance which it has to overcome is exerted by muscles acting much nearer to the fulcrum. Moreover, its direction downwards and backwards is at a considerable angle with the line of the lever, viz. that which joins the prominence of the chin to a point a little above the inferior dental foramen. (4) If the mandible be fixed and both bellies act, the hyoid bone will be drawn directly upwards. By this action the muscle is of great importance in the elevation of the tongue, which rests upon the upper surface of the hyoid bone. It will therefore help in the first part of deglutition, in which the back of the tongue is pressed against the hard palate.

Relations.—The posterior belly lies beneath the mastoid process, the sterno-mastoid, splenius, and trachelo-mastoid muscles, the facial vein, and the parotid gland; in front lies the stylo-hyoid muscle; deeply, the middle constrictor of the pharynx, the hyo-glossus, the external and internal carotid arteries, and some of the branches of the external carotid, the internal jugular vein, the hypoglossal and superior laryngeal nerves.

The *tendon* lies beneath the deep cervical fascia, platysma myoides, and part of the stylo-hyoid muscle. Above is the submaxillary gland. On its deep surface is the rest of the stylo-hyoid muscle, the mylo-hyoid, the hyo-glossus, and the hypoglossal nerve.

The *anterior belly* is covered by the deep cervical fascia and platysma myoides, and it lies upon the mylo-hyoid muscle.

Variations.—A second posterior belly may arise in front of the angle of the mandible; slips may also arise from the styloid process, or the pharynx. The anterior belly may be absent; it may be partly or entirely united with that of the opposite side, or may send a slip to the median raphé of the mylo-hyoid.

2. STYLO-HYOID

The **stylo-hyoid**—named from its attachments—is a slender fusiform muscle with a bifurcated lower extremity.

Origin.—The back and outer surface of the styloid process of the temporal bone near its base.

Insertion.—The lower border of the body of the hyoid bone at the point of union with the great cornu.

Structure.—Arising by a short tendon, its fibres soon become fleshy and pass downwards and forwards. Just before its insertion they divide into two bundles, which form an obliquely directed arch bridging over the tendon of the digastric muscle.

Nerve-supply.—A special branch of the facial nerve, which enters its deep surface from behind.

Action.—The same as that of the posterior belly of the digastric, viz. to draw the hyoid bone backwards and upwards.

Relations.—Superficially, the parotid gland and deep cervical fascia; in front, the submaxillary gland; behind, the posterior belly of the digastric; deeply, the middle constrictor and hyo-glossus and the external carotid artery.

Variations.—The stylo-hyoid may arise in part from the cartilage of the external auditory meatus. It may be absent, or its insertion may be undivided, in which case it may pass to the inner or outer side of the digastric tendon. A second stylo-hyoid may run beneath the hyo-glossus to the lesser cornu of the hyoid bone.

3. MYLO-HYOID

The **mylo-hyoid**—named from its attachment to the lower jaw (μύλη = a mill and the jaw) and to the hyoid bone—is a triangular and somewhat curved sheet.

Origin.—The whole length of the mylo-hyoid ridge on the inner surface of the body of the mandible.

Insertion.—(1) The lower edge of the anterior surface of the body of the hyoid bone; (2) a median raphé extending from the middle of the lower border of the body of the hyoid bone to the back of the symphysis of the mandible immediately below the genial tubercles.

Structure.—Arising by fleshy and short tendinous fibres intermingled, the muscle passes inwards and slightly downwards to its insertion by short tendinous fibres into the median raphé and hyoid bone. Sometimes the fleshy fibres are here and there continuous with those of the other side. Each of them is somewhat arched, so that the whole sheet has a slight downward convexity. The muscles of the two sides together form a curved diaphragm which stretches across the angle contained between the two portions of the mandible.

Nerve-supply.—From the third (or mandibular) division of the fifth cranial nerve, by the mylo-hyoid branch of the inferior dental which enters the under surface of the muscle by several filaments.

Action.—(1) To raise the tongue, the floor of the mouth, and the hyoid bone, as in mastication and the first part of swallowing. By its elevation of the hyoid bone it will also exert some influence on the larynx and lower part of the pharynx. These actions will be most efficiently carried out when the jaw is closed. (2) Acting from below, it will help in the depression of the lower jaw and in opening the mouth.

Relations.—Upon its under surface lie the superficial portion of the submaxillary gland, the submental artery, and the anterior belly of the digastric muscle. Above, it is in contact with the genio-hyoid and hyo-glossus, the sublingual gland, the deep portion of the submaxillary gland, and the hypoglossal nerve.

Variations.—The mylo-hyoid may be closely connected with the anterior belly of the digastric. Openings are sometimes found in the muscular sheet, containing lobules of the submaxillary gland.

4. GENIO-HYOID

The **genio-hyoid**—named from its attachment to the chin (γένειον) and the hyoid bone—is somewhat fusiform, but flattened from above downwards behind, and from side to side in front.

Origin.—The lower genial tubercle.

Insertion.—The anterior surface of the body of the hyoid bone.

Structure.—Arising by a short tendon, its fibres pass backwards and slightly downwards, close to those of the corresponding muscle of the other side. Near the hyoid bone they spread out laterally, and occupy nearly the whole of the upper and anterior surface of the body, sometimes even a small portion of the greater cornu.

Nerve-supply.—The hypoglossal nerve, which sends filaments to the deep surface.

Action.—(1) To raise and draw forwards the hyoid bone; (2) to draw down the mandible. In its direction and action it is closely related to the anterior belly of the digastric.

Relations.—Superficially, the mylo-hyoid muscle; deeply, the genio-hyo-glossus; on its median surface, the corresponding muscle of the other side.

Variations.—The genio-hyoid may be double, or it may form one muscle with its fellow of the opposite side.

THE EXTRINSIC MUSCLES OF THE TONGUE

The tongue consists chiefly of muscular tissue, part of which arises from the adjacent bones, while the rest is made up of bands of fibre which pass in various directions in its substance, and have no external attachment. The latter or **intrinsic** muscles will be described later; the former or **extrinsic** muscles constitute a group which is nearly related to those which have been just described. It consists of four muscles—viz. the genio-hyo-glossus, the hyo-glossus, the stylo-glossus, and the palato-glossus.

1. GENIO-HYO-GLOSSUS

The **genio-hyo-glossus**—named from its attachment to the chin (γένειον), hyoid bone, and tongue (γλῶσσα), is a flat sheet forming the quadrant or, more correctly, the sector of a circle, and separated from its fellow by a thin stratum of connective tissue, the *septum* of the tongue.

Origin.—The upper genial tubercle.

Insertion.—(1) The whole length of the tongue in the submucous tissue just external to the median plane, from the tip along the dorsum to the root; (2) the upper part of the anterior surface of the body of the hyoid bone; (3) by a few fibres into the side of the pharynx.

Structure.—Its origin is by a short tendon, from which its fleshy fibres diverge in a fan-shaped sheet to their extensive insertion.

Nerve-supply.—The hypoglossal, by filaments which enter its outer surface.

Action.—(1) To draw downwards and forwards the mesial portion of the tongue so as to make its dorsum concave upwards in a transverse direction; (2) by its anterior fibres to draw back the tip of the protruded tongue; (3) by fibres which pass to the back part of the dorsum of the tongue to draw it forwards, and protrude the tongue; (4) by its lowest fibres to draw upwards and forwards the hyoid bone, and so help the genio-hyoid and anterior belly of the digastric in raising the tongue; (5) acting from below, its hyoid portion will help in depressing the lower jaw.

Relations.—Externally, the inferior lingualis, hyo-glossus, and stylo-glossus muscles, the ranine artery, the terminal branches of the hypoglossal and lingual gustatory nerves, the mucous membrane of the floor of the mouth, the sublingual gland, and Wharton's duct; internally, the fellow muscle and septum linguæ; along its lower border, the genio-hyoid muscle.

2. HYO-GLOSSUS

The **hyo-glossus**—named from its attachments to the hyoid bone and tongue (γλῶσσα)—is a thin square sheet.

Origin.—(1) From the front of the hyoid bone near the upper border of the outer third of its body; (2) from the upper border of all its great cornu; (3) by a small slip from the lesser cornu.

Insertion.—The submucous tissue and adjacent muscular mass of the posterior half of the tongue external to the preceding muscle.

Structure.—The fleshy fibres arise directly from the bone in a thin sheet, and ascend nearly parallel to one another. The anterior fibres, however, diverge slightly forwards, and they all, having reached the upper surface of the sides of the tongue, course inwards, interlacing with the fibres of the palato-glossus and superficial lingualis to form a submucous cover to the tongue.

Those which arise from the lesser cornu are often described as a distinct muscle, the *chondro-glossus*, which is separated from the rest of the muscle by some bundles which pass from the lower part of the genio-hyo-glossus to the superior constrictor.

Nerve-supply.—The hypoglossal nerve, which sends filaments into its outer surface.

Action.—(1) To draw downwards the sides of the tongue, increasing its transverse convexity; (2) to draw backwards the protruded tongue.

Relations.—Externally, the mylo-hyoid, digastric, stylo-hyoid, and stylo-glossus muscles, the lingual vein, lingual gustatory and hypoglossal nerves, the submaxillary gland and Wharton's duct; deeply, the inferior lingualis, genio-hyo-glossus, middle constrictor, and part of the origin of the superior constrictor, the lingual artery, and glosso-pharyngeal nerve.

3. STYLO-GLOSSUS

The **stylo-glossus**—named from its attachments to the styloid process and tongue (*γλῶσσα*)—is a long, triangular sheet.

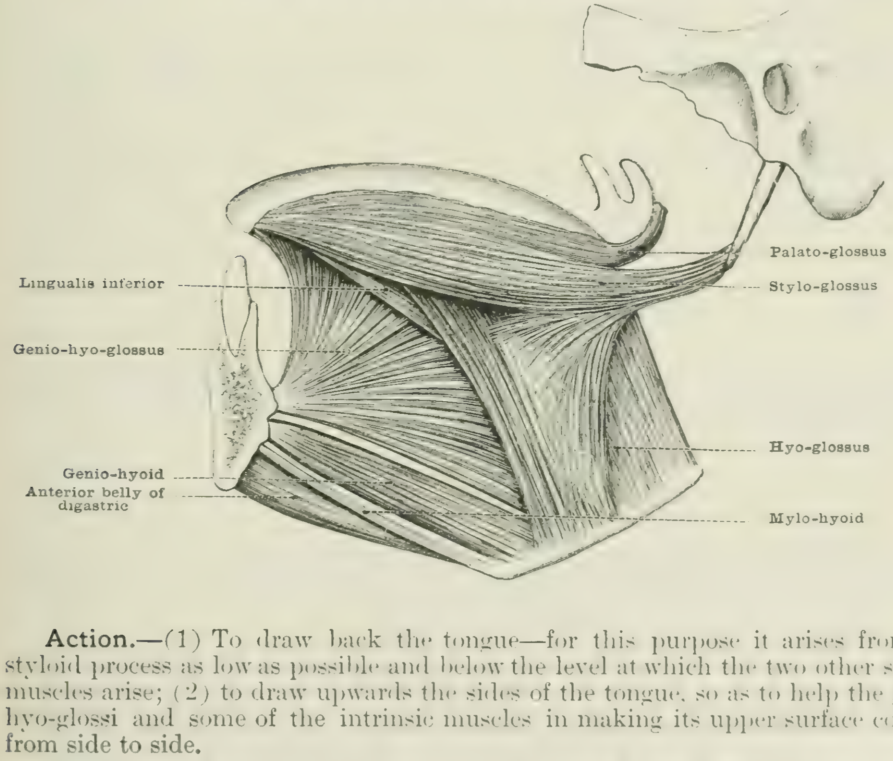
Origin.—(1) The front of the lower part and tip of the styloid process of the temporal bone; (2) the upper part of the stylo-mandibular ligament.

Insertion.—The submucous tissue and subjacent muscular strata of the side of the tongue and the adjacent parts of its under surface.

Structure.—Arising by short tendinous fibres, the muscle soon develops into a long, fan-shaped, laterally-compressed sheet, which passes in a long curve, with an upward concavity, forwards and slightly downwards and inwards to the side of the tongue, where it partly overlaps and partly interlaces with the hyo-glossus muscle, forming with this muscle and some of the fibres of the palato-glossus a thin superficial stratum which is continued forwards to the tip of the tongue.

Nerve-supply.—From the hypoglossal nerve, by filaments which enter its external surface.

FIG. 315.—SIDE VIEW OF THE MUSCLES OF THE TONGUE.



Action.—(1) To draw back the tongue—for this purpose it arises from the styloid process as low as possible and below the level at which the two other styloid muscles arise; (2) to draw upwards the sides of the tongue, so as to help the genio-hyo-glossi and some of the intrinsic muscles in making its upper surface concave from side to side.

Relations.—Superficially, the internal pterygoid, the parotid gland, lingual gustatory nerve, and the mucous membrane of the side of the tongue; deeply, the stylo-pharyngeus, hyo-glossus, inferior lingualis and genio-hyo-glossus, with the glosso-pharyngeal nerve.

4. PALATO-GLOSSUS

The **palato-glossus**—named from its attachment to the soft palate and tongue (*γλῶσσα*)—is a somewhat cylindrical muscle which expands at either end into a thin sheet.

Origin.—The under surface of the aponeurosis of the soft palate; and at the middle line its fibres are continuous with those of its fellow of the opposite side.

Insertion.—(1) The superficial muscular stratum which covers the side and adjacent part of the under surface of the tongue; (2) it is partly continuous with the deep transverse lingualis muscle.

Structure.—Arising in a thin muscular sheet, its fibres form as they pass outwards a small cylindrical bundle which, lying in front of the tonsil and against the wall of the pharynx, constitutes the anterior pillar of the fauces. This bundle runs downwards and forwards till it reaches the side of the tongue at the junction of its middle and posterior thirds. Here some of the fibres pass forwards and downwards to join the superficial stratum formed by the stylo-glossus and hyo-glossus. The rest pass inwards towards the middle line, being continued into the deep transverse lingualis muscle. This part of the two muscles, together with the associated portion of the lingualis transversus, forms a sphincter muscle round the front part of the faucial opening.

Nerve-supply.—Filaments from the pharyngeal plexus.

Action.—(1) To draw downwards the sides of the soft palate; (2) to draw upwards and backwards the sides of the tongue. The combination of these two actions closes the front part of the faucial opening, as in the second part of swallowing, when the back of the tongue comes into contact with the soft palate, and prevents the return of the food which is being grasped by the constrictors. It should be remembered, however, that the elevation of the tongue is chiefly due to the muscles which raise the hyoid bone.

Relations.—Superficially, it is covered by the mucous membrane of the soft palate and the side of the tongue; deeply, it is in contact with the aponeurosis of the soft palate, the superior constrictor of the pharynx, and the hyo-glossus; behind it lies the tonsil.

For Muscles of the Palate see page 944. For Muscles of the Pharynx see pages 950–952.

THE DEEP MUSCLES OF THE FRONT OF THE NECK

The deep muscles of the front of the neck consist of an inner and an outer group, separated from one another by the line of the anterior tubercles of the cervical vertebræ. Both groups are covered in front by the prevertebral fascia.

Outer Group

The *outer group* is formed by the three scaleni, which pass from the first two ribs upwards and inwards to the transverse processes.

1. SCALENUS ANTICUS

The **scalenus anticus**—named from its shape (*scalenus* = of unequal sides, being a term applied to certain triangles in geometry) and its relation to its fellows—is a thick triangular sheet.

Origin.—The scalene tubercle near the inner border of the upper surface of the first rib.

Insertion.—The anterior tubercles of the third, fourth, fifth, and sixth cervical vertebræ.

Structure.—Arising by a short, somewhat flattened tendon, which is continued upwards for a short distance upon the front and outer surface of the muscle, the fleshy fibres diverge as they pass upwards and slightly backwards and inwards to be inserted by four short tendons into the transverse processes.

Nerve-supply.—From the anterior primary branches of the fourth, fifth, and sixth cervical nerves close to their points of emergence.

Action.—(1) The rib being fixed, it will help to flex the neck both forwards and laterally, and to rotate it so as to turn the face to the opposite side; (2) it will raise the first rib, especially in forced inspiration.

Relations.—In front lie the sterno-mastoid, omo-hyoid, and subclavius, the internal jugular vein, the subclavian vein and phrenic nerve; on the inner side are the rectus capitis anticus major, longus colli, the vertebral vessels, and the sympathetic cord; on the outer side and behind emerge the anterior primary branches of the cervical nerves separating it from the scalenus medius; and lower down it crosses in front of the second part of the subclavian artery and the pleura.

2. SCALENUS MEDIUS

The **scalenus medius**—named from its shape and position—is an elongated triangular sheet.

Origin.—The upper surface of the first rib between the tuberosity and the groove for the subclavian artery.

Insertion.—The front of the posterior tubercles of the six lower cervical vertebræ, and frequently also the lower part of the lateral mass of the atlas.

Structure.—Arising by a broad band, tendinous in front and muscular behind, the fleshy fibres form a thick sheet of slightly divergent fibres, which run upwards and inwards to end upon the vertebræ in six short tendons.

Nerve-supply.—The anterior primary branches of the cervical nerves as soon as they emerge supply numerous filaments to the inner part of its anterior surface.

Action.—Acting from below, to flex the neck laterally; acting from above, to raise the first rib as in forced inspiration, or to fix it in ordinary inspiration.

Relations.—In front lie the sterno-mastoid, omo-hyoid, and trapezius, the subclavian artery, cervical and brachial plexuses; behind, it is in contact with the levator anguli scapulæ and scalenus posticus.

3. SCALENUS POSTICUS

The **scalenus posticus**—named from its form and position—is a triangular sheet.

Origin.—The upper part of the outer surface of the second rib behind the rough prominence for the serratus magnus.

Insertion.—The lower surface of the posterior tubercles of the two or three lowest cervical vertebræ.

Structure.—Arising partly directly from the bone, and partly by a short aponeurosis which covers the outer and posterior part of the origin, its fleshy fibres converge and are inserted by three short tendons.

Nerve-supply.—Small filaments which come from the lower three cervical nerves at their points of emergence, and, after passing through the scalenus medius, enter the front service of the muscle.

Action.—When the rib is fixed, to flex the lower part of the neck laterally, and acting from above, to raise the second rib, especially in forced inspiration.

Relations.—In front lies the scalenus medius; behind, the levator anguli scapulæ.

Variations of the scaleni.—The scalenus posticus may be absent. The scalenus medius may arise as low as the third rib. A portion of the scalenus anticus may be separate from the rest, and pass behind the subclavian artery.

INNER GROUP

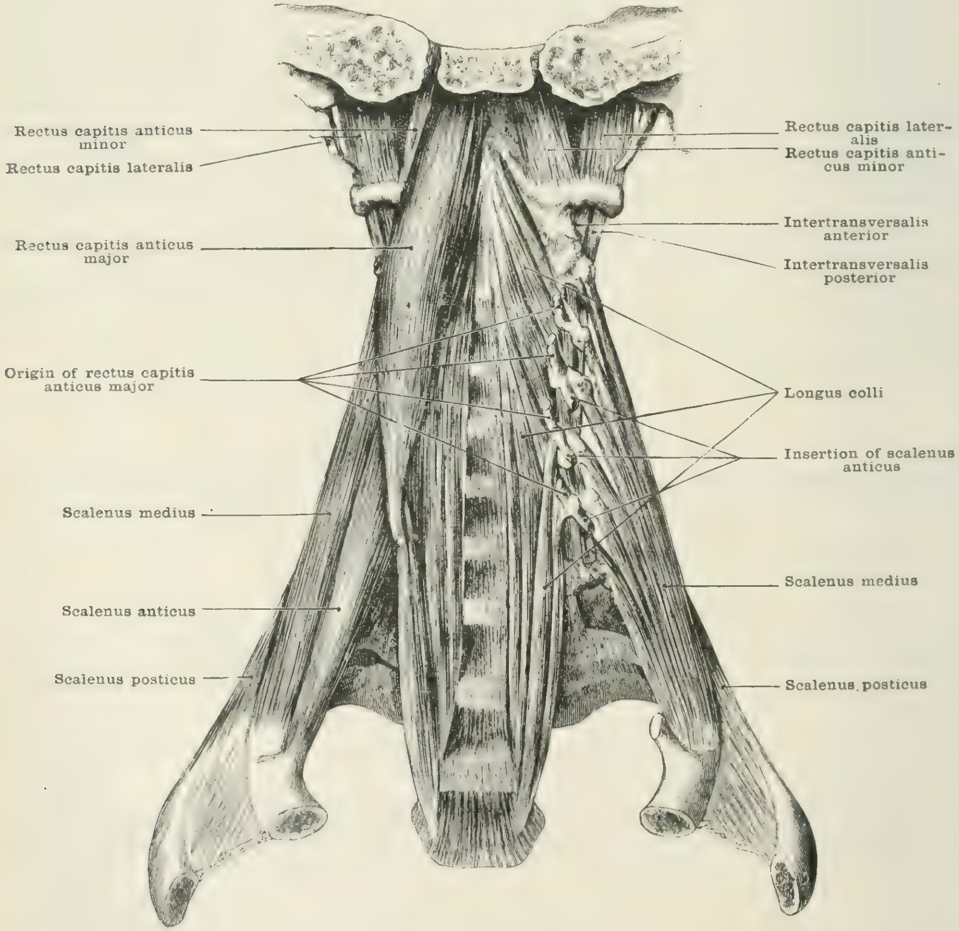
The *inner or prevertebral group* consists of the greater and lesser rectus capitis anticus and the longus colli.

1. RECTUS CAPITIS ANTICUS MAJOR

The **rectus capitis anticus major**—named from its direction, position, and size—is a thick, irregular, quadrilateral sheet.

Origin.—The front of the anterior tubercles of the third, fourth, fifth, and sixth cervical vertebræ.

FIG. 316.—THE MUSCLES OF THE FRONT OF THE NECK.


Rectus capitis anticus minor
Rectus capitis lateralis
Rectus capitis anticus major
Origin of rectus capitis anticus major
Scalenus medius
Scalenus anticus
Scalenus posticus
Rectus capitis lateralis
Rectus capitis anticus minor
Intertransversalis anterior
Intertransversalis posterior
Longus colli
Insertion of scalenus anticus
Scalenus medius
Scalenus posticus

Insertion.—A transverse impression upon the under surface of the basilar process of the occipital bone, extending from just behind the pharyngeal tubercle outwards and somewhat forwards.

Structure.—Arising by four tendinous teeth, the parallel fleshy fibres run upwards and inwards to be inserted directly upon the occipital bone. An incomplete tendinous intersection crosses its anterior surface.

Nerve-supply.—Internal branches from the first and second cervical nerves enter the upper part of its front surface.

Action.—To flex the head, and slightly to rotate it to the same side.

Relations.—In front, the internal and common carotid artery, the internal jugular vein, the pneumogastric and sympathetic nerves, and the upper part of the pharynx; behind, the rectus capitis anticus minor, and part of the longus colli.

2. RECTUS CAPITIS ANTICUS MINOR

The **rectus capitis anticus minor**—named from its direction, position, and size—is thick and ribbon-shaped, and continues the series of the anterior intertransversales.

Origin.—The upper surface of the lateral mass of the atlas in front of the articular process.

Insertion.—The under surface of the basilar portion of the occipital bone in front of the foramen magnum, but not as far inwards as the preceding muscle.

Structure.—Parallel or slightly divergent fleshy fibres which run upwards and inwards.

Nerve-supply.—The first cervical nerve, which sends a filament to its front surface.

Action.—To flex the head.

Relations.—In front, the rectus capitis anticus major; behind, the anterior occipito-axial ligament.

3. LONGUS COLLI

The **longus colli**—named from its length and the region in which it lies—is a compound muscle, and forms an elongated triangular sheet with the base running vertically along the outer border of the anterior common ligament, and the obtuse apex directed outwards. It consists of three portions: one mesial, the *vertical*; and two lateral, the *upper* and *lower oblique portions.*

Vertical portion:—

Origin.—Lateral part of front of bodies of last two cervical and first three thoracic vertebræ, external to the anterior common ligament.

Insertion.—Lateral part of front of bodies of second, third, and fourth cervical vertebræ.

Lower oblique portion:—

Origin.—Lateral part of front of bodies of the first three thoracic vertebræ.

Insertion.—The front of the anterior tubercles of the transverse processes of the fifth and sixth cervical vertebræ.

Upper oblique portion:—

Origin.—The front of the anterior tubercles of the transverse processes of the third, fourth and fifth cervical vertebræ.

Insertion.—The under surface and side of the anterior tubercle of the atlas.

Structure.—All three portions arise by short tendons, then become fleshy, and are inserted by short tendons, with the exception of the superior oblique portion, which has a fleshy attachment to the tubercle of the atlas.

Nerve-supply.—The anterior branches from the cervical nerves soon after their emergence.

Action.—To flex the neck; and also by its oblique portions slightly to rotate and laterally flex it.

Relations.—In front, the pharynx, œsophagus, great vessels of the neck, the inferior thyroid artery, the sympathetic cord, the pneumogastric nerve, and the recurrent laryngeal nerve; behind, the vertebral column, and, under cover of the lower oblique portion, the vertebral artery.

ABNORMAL MUSCLES

By J. BLAND SUTTON, F.R.C.S.

ASSISTANT SURGEON TO THE MIDDLESEX HOSPITAL, AND SURGEON TO THE CHELSEA HOSPITAL FOR WOMEN

Revised and Added to by ARTHUR ROBINSON, M.D., Lecturer on Anatomy at the Middlesex Hospital

The **abductor ossis metatarsi quinti** *arises* from the outer tubercle of the calcaneum.

It is *inserted* into the tuberosity at the base of the fifth metatarsal bone. The origin and insertion are marked in fig. 167. It is present in two out of every three subjects, and when not represented by muscle fibres its place is occupied by a band of fibrous tissue.

Agitator caudæ is a small slip of muscles which arises from the last piece of the sacrum or from the side of the coccyx. It is inserted into the femur below the gluteus maximus.

Amygdalo-glossus.—A small muscle which *arises* from the side of the tongue and is *inserted* into the outer surface of the tonsil.

The **anomalus** *arises* from the nasal process of the maxilla, beneath the *levator labii superioris alæque nasi.* It is *inserted* into the maxilla close to the origin of the *compressor naris.*

The **atlanto-mastoid** *arises* from the transverse process of the atlas, between the superior oblique and the rectus capitis lateralis. It is *inserted* into the posterior part of the mastoid process.

Azygos pharyngis.—This muscle *arises* from the pharyngeal tubercle on the under surface of the body of the occipital bone.

It is *inserted* into the raphé of the pharynx superficial to the insertion of the superior and middle constrictor muscles. It may blend with the ascending fibres of the middle constrictor. It is often represented by a fibrous band. [For figure, see Macalister, *Proc. Royal Irish Academy,* vol. ix.]

The **chondro-epitrochlearis** *arises* from the cartilages of one or two ribs (usually the seventh), or from the aponeurosis of the external oblique muscle.

It is *inserted* into the fascia on the inner side of the arm, or into the intermuscular septum, and sometimes into the internal condyle of the humerus. [For figure, see Perrin, *Journ. of Anat. and Phys.* vol. v. plate ix.]

The **cleido-hyoid** *arises* from the clavicle near the outer border of the sterno-hyoid.

It is *inserted* into the body of the hyoid superficial to the sterno-hyoid.

The **cleido-occipitalis** *arises* from the clavicle posterior to the sterno-mastoid and anterior or external to the cleido-mastoid. It runs upwards parallel with the posterior border of the sterno-mastoid to be *inserted* into the superior nuchal line of the occipital bone anterior to the origin of the trapezius. [Perrin; a good figure in *Journ. of Anat. and Phys.* vol. v. p. 253.]

The **costo-coracoideus** *arises* from one or more ribs, between the pectoralis major and the latissimus dorsi, and is *inserted* into the coracoid process.

The **costo-fascialis** is a muscular slip given off from the outer border of the sterno-thyroid near its origin.

It is *inserted* into the sheath of the carotid vessels, and sometimes reaches as high as the level of the thyroid cartilage.

The **curvator coccygis** *arises* from the anterior surface of the fifth piece of the sacrum.

It is *inserted* into the anterior surface of the coccyx. [For figure, see M. Watson, *Journ. of Anat. and Phys.* vol. xiv. p. 407.]

The **depressor thyroideæ** *arises* from the lower border of the first ring of the trachea quite close to the middle line.

It passes vertically upwards to be *inserted* into the lower border of the thyroid cartilage internal to the crico-thyroid. [The muscle is figured by Messenger Bradley in *Journ. of Anat. and Phys.* vol. vi. p. 420.]

The **dorso-epitrochlearis** is a muscular slip given off by the tendon of the latissimus dorsi at the axilla. Sometimes it is directly continuous with a *chondro-epitrochlearis* muscle.

It is *inserted* into the long head of the triceps, or into the fascia of the arm, and sometimes into the internal intermuscular septum. [For figure, see Perrin, *Journ. of Anat. and Phys.* vol. v. plate x.]

The **epitrochleo-anconeus** is a small muscle *arising* from the back of the internal condyle of the humerus, and passing over the ulnar nerve is *inserted* into the inner side of the olecranon.

This is the most frequent of all the muscles to which the term 'abnormal' is applied. [For figure, see Wood, *Proc. Roy. Soc.* vol. xv. p. 521.]

The **extensor annularis** *arises* from the posterior surface of the ulnar shaft below the extensor indicis. When an extensor medius is also present, it will arise in common with the annularis.

The tendon passes under the annular ligament with the common extensor, and is *inserted* into the tendon of the ring (fourth) finger.

The **extensor brevis digitorum manus** *arises* from the ligamentous tissues on the back of the carpus, or from one of the bones of the forearm, or from the posterior annular ligament. It passes under the posterior annular ligament, and gives off three slips which blend with the tendons of the third, fourth, and fifth digits.

The **extensor carpi radialis accessorius** *arises* from the humerus below the extensor carpi radialis longior.

It is *inserted* into the metacarpal bone of the thumb, or into the abductor pollicis, or into the first dorsal interosseous muscle.

Extensor carpi radialis intermedius.—This muscle usually *arises* from one or both the radial extensors of the carpus, and more rarely from the humerus. It is *inserted* into the second or third metacarpal bone.

The **extensor coccygis** *arises* from the posterior surface of the last piece of the sacrum.

It is *inserted* into the posterior surface of the coccyx.

The **extensor medii digiti** *arises* from the ulna below the extensor indicis, or from the posterior annular ligament. It is *inserted* into the extensor expansion of the middle finger.

The **extensor ossis metatarsi hallucis** *arises* as a slip from the *extensor proprius hallucis* or from the *extensor communis digitorum*, or from the *tibialis anticus*. It may arise as a separate muscle close to the *extensor proprius*.

It is *inserted* into the metatarsal bone of the hallux.

The **extensor primi internodii hallucis longus** is usually an offset from the *extensor proprius*, but it may arise separately from the fibula and interosseous membrane or from the tibialis anticus.

It is *inserted* into the inner part of the base of the first phalanx of the hallux. [See Wood, *Proc. Roy. Soc.* vol. xv. p. 535.]

The **flexor accessorius longus** *arises* from the fascia over the flexor longus hallucis, or from the fibula or tibia; it passes with the tendon of this muscle beneath the internal annular ligament; and ends in a tendon which crosses the long plantar ligament obliquely, to be *inserted* into the sesamoid bone in the tendon of the *peroneus longus*, or it joins the long flexor or the accessorius.

When this muscle is present, the accessorius is sometimes absent. [For figure, see Thane, *Proc. Anat. Soc. of Gt. Britain and Ireland*, May 1891.]

The **flexor carpi radialis brevis vel profundus** *arises* from the front surface of the radius near the anterior border, above the pronator quadratus, but below the flexor longus pollicis.

The *insertion* is very variable: in some cases it only reaches the annular ligament, whilst in others it passes under this structure to be inserted into the trapezium, magnum, or the base of the second or third metacarpal bones. [For figure, see Wood, *Journ. of Anat. and Phys.* vol. i. p. 57.]

The **gluteo-perinealis** *arises* from the fascia at the lower border of the gluteus maximus. It joins the transversus perinei or is *inserted* into the triangular ligament.

The **gluteus quartus** *arises* from the anterior part of the inferior gluteal ridge of the ilium; it lies in close contact with the capsular ligament of the hip-joint.

It is *inserted* into the top of the great trochanter of the femur anterior to the insertion of the gluteus minimus. [For good figure, see Gruber, *Virchow Arch.* bd. cvii. s. 480.]

Hyo-epiglottideus.—This muscle *arises* from the middle of the ridge on the lingual aspect of the epiglottis.

It is inserted into the median tubercle on the body of the hyoid bone. It is often represented by a fibrous band. [See *Journ. of Anat. and Phys.* vol. xxiii. p. 256.]

The **iliacus minor, or ilio-capsularis,** *arises* from the anterior inferior spine of the ilium.

It is *inserted* into the lower part of the anterior intertrochanteric line, or into the ilio-femoral portion of the capsule.

The **interclavicular muscle** usually consists of two fleshy bellies with a stout intermediate tendon. It *arises* from the clavicle, anterior to the attachment of the rhomboid ligament and from the ligament itself.

It is *inserted* into a corresponding position on the opposite clavicle, and fills up the gap between the sternal ends of the clavicles. [Lane, *Journ. of Anat. and Phys.* vol. xx. p. 544.]

The **interosseus primus volaris** is a slender muscle *arising* from the ulnar side of the base of the first metacarpal bone.

It is *inserted* into the side of the base of the first phalanx of the thumb in common with the adductor pollicis.

Its origin and insertion are marked in fig. 135, p. 130.

The **ischio-aponeuroticus, or tensor fasciæ cruralis,** *arises* from one of the hamstring muscles, and is *inserted* into the fascia on the back of the leg.

Kerato-thyroid.—A short, slender muscle *arising* from the lower border of the cricoid cartilage behind the articular facet.

It is *inserted* into the inferior cornu of the thyroid cartilage.

The **levator claviculæ** *arises* from the transverse processes of the first and second cervical vertebræ; it appears as a dismemberment of the *levator anguli scapulæ*.

It is *inserted* into the outer half of the clavicle.

Levator glandulæ thyroideæ. This muscle *arises* from the isthmus, but more frequently from the pyramidal process of the thyroid body.

It is *inserted* into the anterior surface of the body of the hyoid bone. Frequently it is connected with the thyro-hyoid muscle, and occasionally with the sterno-thyroid.

The **mento-hyoideus** is a slip of muscle which arises from the body of the hyoid bone. Sometimes it consists of two parallel slips.

It is *inserted* into the symphysis superficial to the mylo-hyoid muscle.

The **mylo-glossus**, a small accessory slip of the stylo-glossus, *arises* from the angle of the mandible, or from the stylo-maxillary ligament.

It is *inserted* into the side of the tongue between the stylo- and hyo-glossus muscles. [For figure, see Wood, *Proc. Roy. Soc.* vol. xv. p. 523.]

Obliquus inferior accessorius.—A small muscular slip which passes from the inferior rectus to the inferior oblique muscle.

The **occipitalis minor** *arises* from the fascia over the occipital origin of the trapezius and terminates in the fascia over the insertion of the sterno-mastoid.

The **occipito-hyoid** *arises* from the mastoid process of the temporal bone and adjacent portion of the superior nuchal line. It passes superficially across the sterno-mastoid near its origin, to be *inserted* into the hyoid bone near the junction of the cornua with the basi-hyoid, and in close association with the posterior belly of the digastric. [Perrin: good figures in *Journ. of Anat. and Phys.* vol. v. pp. 251–3.]

The **occipito-scapular**, or **rhomboideus occipitalis**, *arises* from the occipital bone on a level with the splenius capitis under cover of the trapezius. It passes downwards to be *inserted* into the posterior border of the scapula at the base of the spine. [For figure, see Wood, *Proc. Roy. Soc.* vol. xv. p. 521.]

The **opponens hallucis** *arises* from the oblique adductor of the great toe, and is *inserted* into the first metatarsal bone.

The **opponens minimi digiti pedis** *arises* from the flexor brevis minimi digiti and is *inserted* into the fifth metatarsal bone.

Pectoralis minimus.—A rare muscle which *arises* from the cartilage of the first rib, and is *inserted* into the coracoid process.

The **peroneo-calcaneus internus** *arises* from the lower part of the flexor (posterior) surface of the fibula, external to the origin of the flexor longus hallucis. Its tendon passes beneath the internal annular ligament with the tendon of the flexor longus hallucis, to be *inserted* into the fore part of the inner surface of the calcaneum. [For figure and reference, see Thane, *Proc. Anat. Soc. of Gt. Britain and Ireland*, May 1891.]

The **peroneo-tibialis** *arises* from the inner side of the head of the fibula.

It is *inserted* into the upper extremity of the oblique line of the tibia beneath the popliteus.

The **peroneus accessorius** *arises* from the fibula, between the peroneus longus and the peroneus brevis, and joins the tendon of the longus in the sole of the foot.

The **peroneus quartus** *arises* from the flexor surface of the fibula between the *peroneus brevis* and *flexor longus hallucis*.

It is *inserted* into the ridge of the cuboid, peroneo-cuboideus, or into the peroneal tubercle of the calcaneum, peroneo-calcaneus externus.

The **peroneus quinti digiti** *arises* from the lower fourth of the fibula under cover of the peroneus brevis.

It is *inserted* into the aponeurosis on the extensor surface of the little toe. [Wenzel Gruber has devoted a monograph to this muscle, entitled *Musculus Peronei Digiti V.* Berlin, 1886.]

The **petro-pharyngeus** *arises* from the vaginal process of the temporal bone and is *inserted* into the pharynx.

The **pharyngo-mastoideus** *arises* from the mastoid process and is *inserted* into the pharynx.

The **pisi-annularis** *arises* from the pisiform bone and is *inserted* into the annular ligament.

The **pisi-metacarpeus** *arises* from the pisiform bone and is *inserted* into the fifth metacarpal. It frequently forms part of the abductor minimi digiti.

The **pisi-uncinatus** *arises* from the pisiform bone and is *inserted* into the hook of the unciform.

The **popliteus minor** *arises* from the femur to the inner side of the plantaris.

It is *inserted* into the posterior ligament of the knee-joint.

The **psoas parvus** *arises* from the bodies of the last thoracic and first lumbar vertebræ and from the disc between them.

It is *inserted* by means of a thin flat tendon into the ilio-pectineal line. This muscle is frequently present.

The **pterygoideus proprius** *arises* from the crest on the greater wing of the sphenoid.

It is *inserted* into the posterior border of the external pterygoid plate, and occasionally into the tuberosity of the maxilla. [For figure, see Wagstaffe, *Journ. of Anat. and Phys.* vol. v. p. 282.]

The **pterygo-pharyngeus externus** *arises* from the hamular process of the sphenoid bone and is *inserted* into the pharynx.

The **pterygo-spinous** *arises* from the alar spine of the sphenoid.

It is *inserted* into the posterior margin of the external pterygoid plate. This muscle is sometimes replaced by ligament.

The **pubo-transversalis** *arises* from the ilio-pectineal line behind the conjoined tendon, and is *inserted* into the transversalis fascia, the aponeurosis of the transversalis muscle or the outer end of the semilunar fold of Douglas.

Rectus abdominis lateralis.—This muscle consists of vertical fibres passing from the lower ribs to the upper part of the ilium between the oblique abdominal muscles.

The **rectus capitis anticus medius** *arises* from the middle of the anterior surface of the body of the axis near its lower border by means of a tendon. As it passes vertically upwards, it bifurcates, each fleshy belly being *inserted* into the basilar process of the occipital bone immediately in front of the foramen magnum, posterior to the insertion of the rectus capitis anticus major, and internal to that of the rectus capitis anticus minor. [Walsham, *Journ. of Anat. and Phys.* vol. xviii. p. 461.]

The **rhombo-atloideus** *arises* from the lower cervical or upper dorsal spines, superficial to the serratus posticus superior, and is *inserted* into the transverse process of the atlas.

The **rotator humeri** *arises* from the under surface and outer border of the coracoid process of the scapula.

It passes across the tendon of the subscapularis, to be *inserted* into the neck of the humerus, below the lesser tuberosity, and between the insertions of the subscapularis and the conjoined tendons of the latissimus dorsi and teres major muscles.

The rotator humeri is a part of the coraco-brachialis muscle, and is often referred to as the coraco-brachialis superior vel brevis. [For figure, see Wood, *Journ. of Anat. and Phys.* vol. i. p. 47.] The insertion of this muscle is indicated in fig. 125.

The **spheno-pharyngeus** *arises* from the spine of the sphenoid and is *inserted* into the wall of the pharynx.

The **spinalis cervicis** *arises* from the ligamentum nuchæ and the first dorsal spine. It is *inserted* into the spine of the axis, and occasionally into the spines of the third and fourth cervical vertebræ.

The **sternalis muscle (rectus sternalis)** *arises* from the sheath of the rectus abdominis, or from the tissues covering the fifth and sixth costal cartilages.

The direction of the fibres is very variable. In some cases they are directed obliquely outwards; in others, they pass vertically upwards to be inserted into the fascia covering the origin of the sterno-mastoid, or into the aponeurosis of the pectoralis major, or into the upper part of the manubrium of the sternum. A sternalis may be present on each side. In some instances they are entirely muscular; in others, furnished with terminal tendons. [See *Journ. of Anat. and Phys.* vols. i. 246, xviii. p. 208, xix. p. 311.]

The **sterno-clavicularis** *arises* from the front of the manubrium sterni, and is *inserted* into the clavicle, between the pectoralis major and the costo-coracoid membrane.

The **stylo-auricularis** *arises* from the cartilage of the external auditory meatus and is *inserted* into the styloid process of the stylo-glossus muscle.

The **subscapularis minor** *arises* from the axillary border of the scapula and is *inserted* into the capsular ligament or the adjacent part of the inner margin of the bicipital groove.

The **supraclavicularis** *arises* by a slender tendon from the upper border of the manubrium of the sternum. It passes outwards, above the sterno-clavicular joint, behind the sterno-mastoid muscle, to be *inserted* into the clavicle. When present in both sides, the muscle sometimes fuses in the middle line.

Supracostalis.—When this muscle is present it extends from the anterior end of the first to the anterior ends of the third or fourth ribs. It may be connected also with the deep fascia of the neck or the scalene muscles.

The **syndesmo-pharyngeus** *arises* from the lateral thyro-hyoid ligament and is *inserted* into the middle constrictor.

The **tibialis secundus** *arises* from the back of the tibia below the flexor longus digitorum and is *inserted* into the back of the capsule of the ankle-joint or into the annular ligament.

The **tibio-fascialis anticus** *arises* from the lower third of the anterior border of the tibia.

It is *inserted* into the annular ligament and deep fascia.

Transversus menti.—A muscular band extending between the adjacent borders of the depressor muscles of the lower lip.

The **transversus nuchæ** *arises* from the external occipital protuberance and is *inserted* into the fascia of the sterno-mastoid.

The **triticeo-glossus** *arises* from the cartilago triticea in the thyro-hyoid ligament.

It is *inserted* into the side of the tongue, blending with the posterior fibres of the hyoglossus.

The **ulnaris quinti digiti** *arises* from the lower part of the ulna or from the extensor carpi ulnaris. It is *inserted* into the metacarpal bone of the little finger or it may join the tendon of the extensor minimi digiti.

SECTION IV

ARTERIES, VEINS, AND LYMPHATICS

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THE ARTERIES

THE **arteries** are divided into the **pulmonary** and the **systemic.** The pulmonary convey the blood from the right ventricle of the heart to the lungs, whence it is returned, when aërated, by the pulmonary veins to the left auricle, and through that cavity into the left ventricle. The systemic arteries carry the blood from the left ventricle all over the body, whence it is returned by the venæ cavæ to the right auricle, and through it to the right ventricle. The lungs also receive blood from the systemic arteries—the bronchial. This blood which serves for the nourishment of the larger and smaller branches of the bronchial tubes and the lung substance is returned, in part by the bronchial veins to the general venous circulation, and thence to the right side of the heart; and in part by the pulmonary veins, along with the aërated blood, to the left side of the heart.

THE PULMONARY ARTERY

The **pulmonary artery** (fig. 317) passes from the right ventricle to the lungs. It differs from all other arteries in the body in that it contains venous blood. It arises as a short, thick trunk from the upper and front part of the right ventricle known as the **conus arteriosus,** and, after a course of about two inches within the pericardium—the serous layer of which membrane forms a common sheath for it and the aorta—divides into a right and a left branch. These branches pierce the pericardium, and pass to the right and left lung respectively.

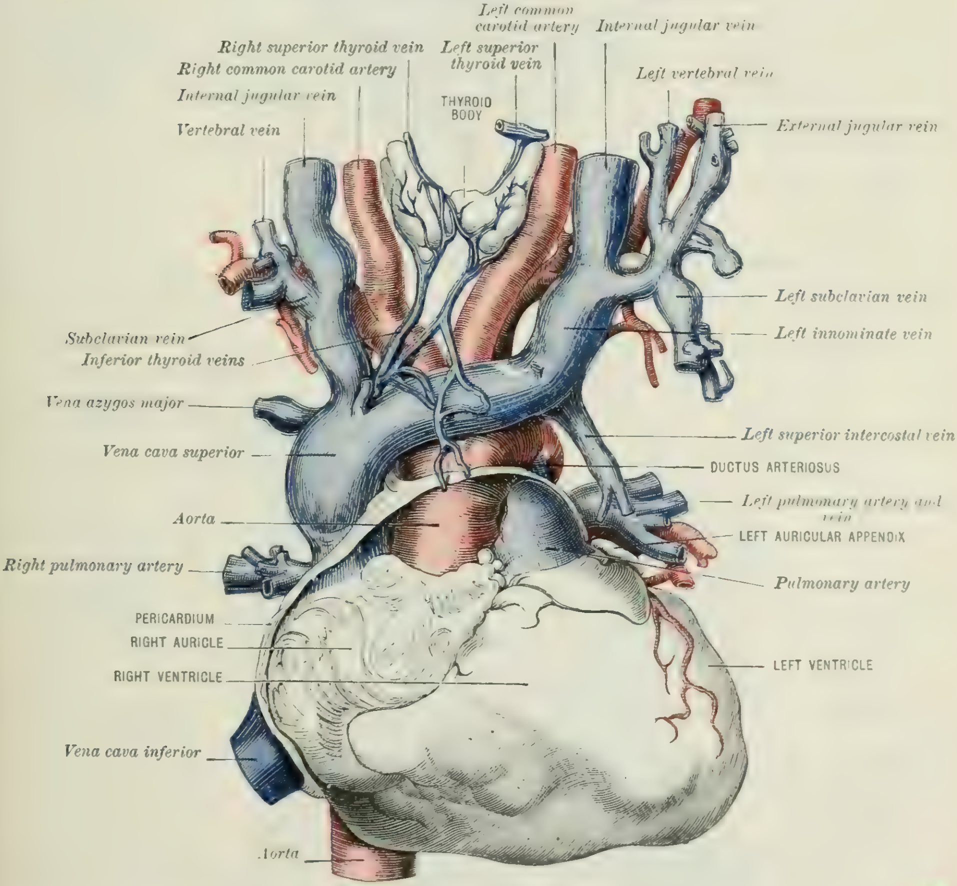
The **trunk of the pulmonary artery** at its origin (fig. 319) is on a plane anterior to the first portion of the arch of the aorta, and slightly overlaps that vessel. Thence it passes upwards, backwards, and to the left, forming a slight curve round the front and left side of the ascending portion of the aorta (fig. 321); and, having reached the concavity of the transverse portion of the aortic arch, on a level with the fifth thoracic vertebra, and on a plane posterior to the ascending aorta, it divides into its right and left branches, which diverge from each other at an angle of about 130°.

In the fœtus, the pulmonary artery (fig. 318) continues its course upwards, backwards, and to the left, under the name of the **ductus arteriosus,** or **ductus Botalli,** and opens into the descending aorta just below the origin of the left subclavian artery. After birth, that portion of the pulmonary artery which extends to the aorta becomes obliterated, and remains merely as a fibrous cord.

The trunk of the artery with the ductus Botalli was originally the left fifth aortic arch, and the recurrent laryngeal nerve in early fœtal life passed below it direct to the larynx. As in the process of development the heart descends into the thorax, and the fifth arch assumes a more vertical direction, it comes to pass that the nerve winds round the transverse portion of the aorta, the fourth aortic arch, and consequently external to the ductus arteriosus (fig. 321). In adult life the cord formed by the obliterated ductus arteriosus arises a little to the left of the bifurcation of the pulmonary artery, and receives a slight reflexion from the pericardium as it pierces that membrane. It occasionally remains partially unobliterated.

Fig. 317.—Anterior View of the Heart with the Large Arteries and Veins.

(By permission. Royal College of Surgeons Museum.)


Left common carotid artery
Internal jugular vein
Right superior thyroid vein
Left superior thyroid vein
Right common carotid artery
Left vertebral vein
Internal jugular vein
THYROID BODY
Vertebral vein
External jugular vein
Left subclavian vein
Subclavian vein
Left innominate vein
Inferior thyroid veins
Vena azygos major
Left superior intercostal vein
Vena cava superior
DUCTUS ARTERIOSUS
Left pulmonary artery and vein
Aorta
LEFT AURICULAR APPENDIX
Right pulmonary artery
Pulmonary artery
PERICARDIUM
RIGHT AURICLE
LEFT VENTRICLE
RIGHT VENTRICLE
Vena cava inferior
Aorta

Relations.—In front, the trunk of the pulmonary artery is covered by the second bone of the sternum, the remains of the thymus gland, and the pericardium (fig. 319), and at its commencement lies immediately behind the anterior extremity of the second intercostal space, the left lung and pleura intervening.

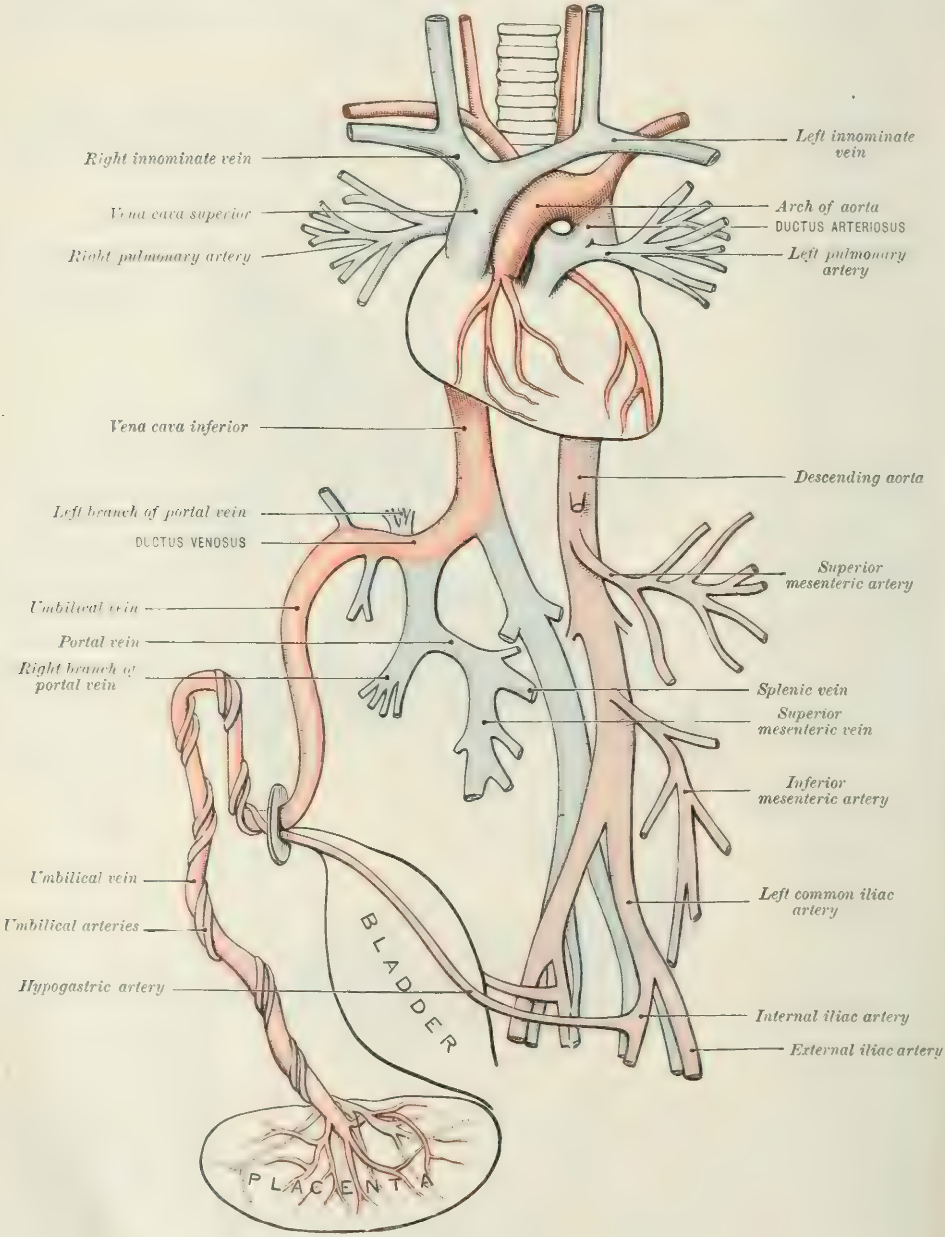
Behind, it lies successively upon the ascending part of the arch of the aorta and the left auricle.

To the **right** are the ascending aorta, the right auricular appendix, the right coronary artery, and the cardiac nerves.

To the **left** are the pericardium, the left pleura and lung, the left auricular appendix, the left coronary artery, and the cardiac nerves.

Fig. 318.—The Heart, with the Arch of the Aorta, the Pulmonary Artery, the Ductus Arteriosus, and the Vessels concerned in the Fœtal Circulation.

(From a preparation of a fœtus in the Museum of St. Bartholomew's Hospital.)


Right innominate vein
Vena cava superior
Right pulmonary artery
Vena cava inferior
Left branch of portal vein
DUCTUS VENOSUS
Umbilical vein
Portal vein
Right branch of portal vein
Umbilical vein
Umbilical arteries
Hypogastric artery
Left innominate vein
Arch of aorta
DUCTUS ARTERIOSUS
Left pulmonary artery
Descending aorta
Superior mesenteric artery
Splenic vein
Superior mesenteric vein
Inferior mesenteric artery
Left common iliac artery
Internal iliac artery
External iliac artery
BLADDER
PLACENTA

THE RIGHT PULMONARY ARTERY

The **right pulmonary artery** (figs. 319 and 320), longer than the left, passes almost horizontally outwards under the arch of the aorta to the root of the right

FIG. 319.—DIAGRAM OF THE RELATIONS OF THE PULMONARY ARTERY AND ITS RIGHT AND LEFT BRANCHES. (Walsham.)

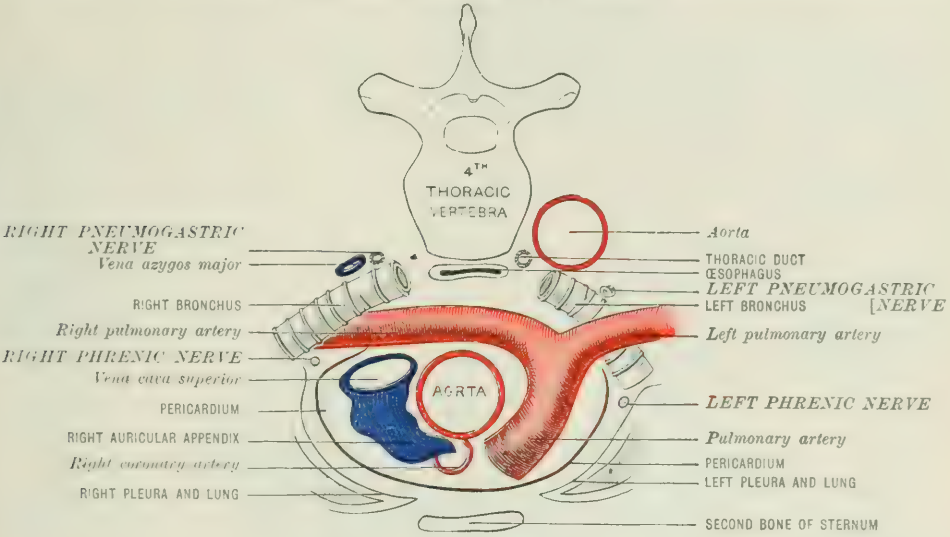
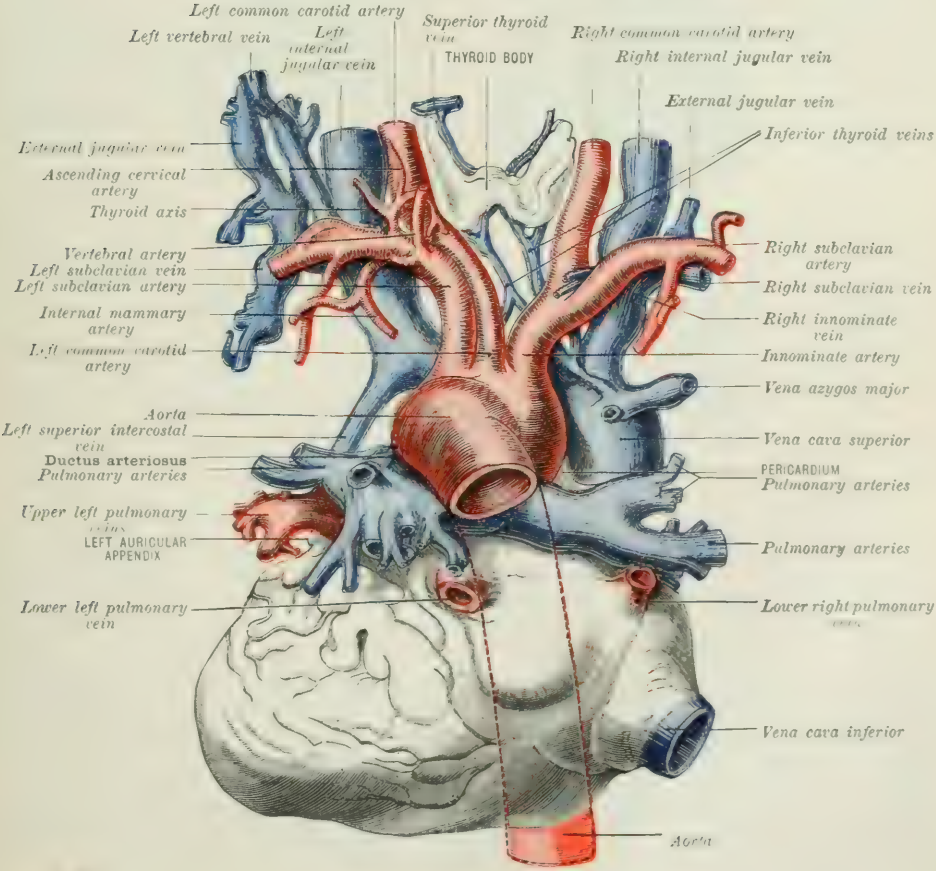

4TH THORACIC VERTEBRA
RIGHT PNEUMOGASTRIC NERVE
Vena azygos major
RIGHT BRONCHUS
Right pulmonary artery
RIGHT PHRENIC NERVE
Vena cava superior
PERICARDIUM
RIGHT AURICULAR APPENDIX
Right coronary artery
RIGHT PLEURA AND LUNG
AORTA
Aorta
THORACIC DUCT
ŒSOPHAGUS
LEFT PNEUMOGASTRIC [NERVE
LEFT BRONCHUS
Left pulmonary artery
LEFT PHRENIC NERVE
Pulmonary artery
PERICARDIUM
LEFT PLEURA AND LUNG
SECOND BONE OF STERNUM

FIG. 320.—POSTERIOR VIEW OF HEART AND GREATER VESSELS. (By permission. Royal College of Surgeons Museum.)


Left common carotid artery
Left vertebral vein
Left internal jugular vein
Superior thyroid vein
THYROID BODY
Right common carotid artery
Right internal jugular vein
External jugular vein
Inferior thyroid veins
External jugular vein
Ascending cervical artery
Thyroid axis
Vertebral artery
Left subclavian vein
Left subclavian artery
Internal mammary artery
Left common carotid artery
Aorta
Left superior intercostal vein
Ductus arteriosus
Pulmonary arteries
Upper left pulmonary veins
LEFT AURICULAR APPENDIX
Lower left pulmonary vein
Right subclavian artery
Right subclavian vein
Right innominate vein
Innominate artery
Vena azygos major
Vena cava superior
PERICARDIUM
Pulmonary arteries
Pulmonary arteries
Lower right pulmonary vein
Vena cava inferior
Aorta

lung, where it divides into a larger upper branch, which supplies the upper lobe and gives off a descending branch to the middle or third lobe, and into a smaller inferior branch for the supply of the inferior lobe. These branches follow the course of the bronchi, dividing and subdividing for the supply of the lobules of the lung. The terminal branches do not anastomose with each other.

Relations.—In its course to the lung it has **in front** of it (fig. 319) the ascending aorta, the vena cava superior, the phrenic nerve, the anterior pulmonary plexus, and the reflexion of the pleura. **Behind** are the right bronchus and the termination of the vena azygos major. **Above** is the transverse portion of the arch of the aorta, and **below** are the left auricle and the upper right pulmonary vein.

At the root of the lung it has the right bronchus **above** and **behind** it; the pulmonary veins **below** and **in front.** Crossing in front of it and the other structure forming the root of the lung are the phrenic nerve and the anterior pulmonary plexus; behind are the vena azygos major, the pneumogastric nerve, and the posterior pulmonary plexus (fig. 324).

THE LEFT PULMONARY ARTERY

The **left pulmonary artery,** shorter and slightly smaller than the right, passes in front of the descending aorta to the root of the left lung, where it divides into two branches for the supply of the upper and lower lobes respectively. These divide and subdivide as on the right side (fig. 319).

Relations.—At the root of the lung it has the left bronchus **behind** and also **below** it in consequence of the more vertical direction taken by the left bronchus than by the right. **Below** and **in front** are the pulmonary veins, while between the artery and the upper left pulmonary vein the vestigial fold of Marshall is to be seen. Crossing in front of it and the other structures forming the root of the lung are the phrenic nerve, the anterior pulmonary plexus, and the reflexion of the left pleura; crossing behind, are the descending aorta, the left pneumogastric nerve, and the posterior pulmonary plexus (fig. 324).

THE SYSTEMIC ARTERIES

THE AORTA

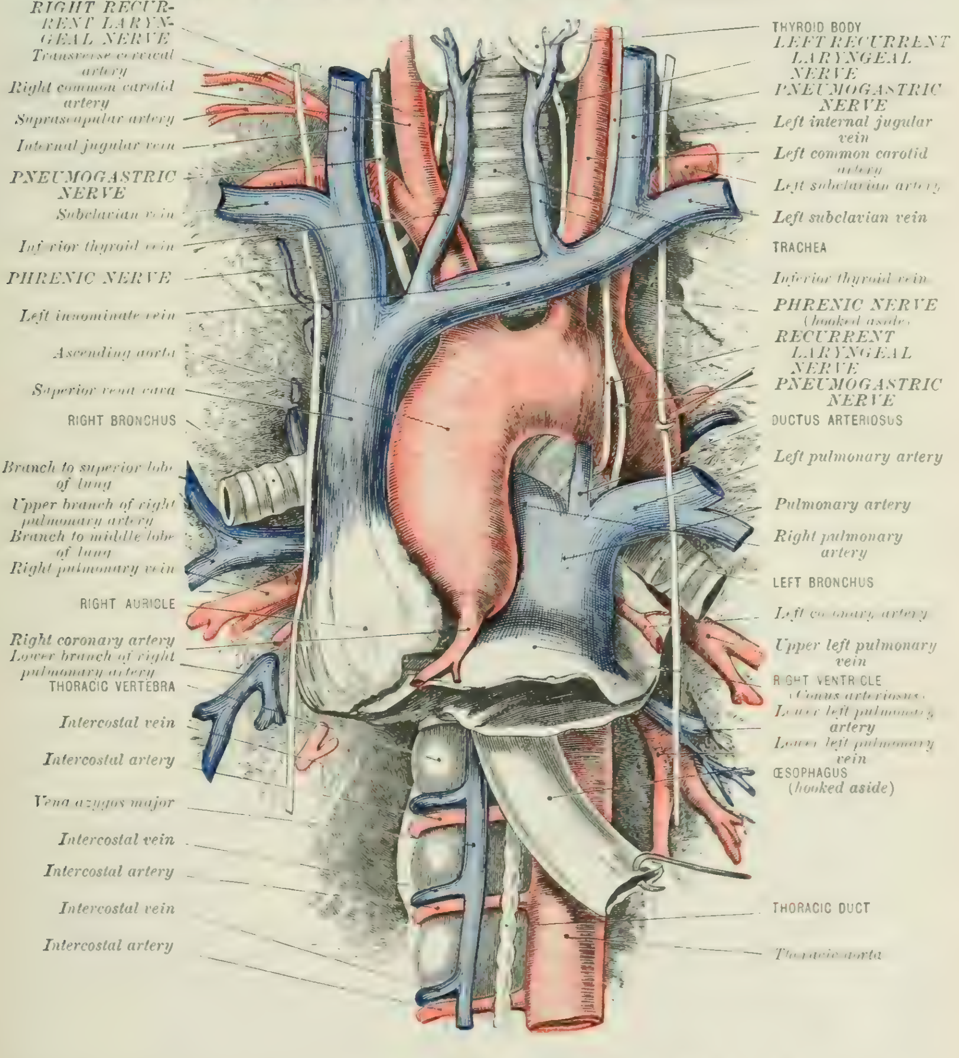
The **aorta** is the main systemic arterial trunk, and from it all the systemic arteries are derived. It begins at the left ventricle of the heart, and, after running a short distance upwards and to the right, turns backwards and to the left, and then downwards, forming the **arch of the aorta.** It is thence continued through the thorax as the **thoracic aorta,** and finally enters the abdomen at the aortic opening in the diaphragm, and, passing through the abdominal cavity under the name of the **abdominal aorta,** terminates opposite the fourth lumbar vertebra in the right and left common iliac arteries. From the point of bifurcation a small vessel is continued down the middle line in front of the sacrum and coccyx, and ends in the coccygeal glomerulus. This vessel (known as the **middle sacral**) is usually regarded, morphologically, as the **sacral** and **coccygeal aorta**; while the coccygeal glomerulus is believed to represent the rudiments of the **caudal aorta,** with probably a persistent part of the post-anal gut.

THE ARCH OF THE AORTA

The **arch of the aorta** (fig. 321) begins at the upper and back part of the left ventricle of the heart, behind the sternum, on a level with the lower border of the third left costal cartilage. Thence it passes upwards and slightly forwards and to the right, as high as the level of the upper border of the second costal cartilage of the right side; and then, curving backwards, upwards, and to the left, crosses behind the sternum at the level of the middle of the manubrium; and, reaching the left side of the body of the fourth thoracic vertebra, runs downwards on the side of the body of that and the fifth thoracic vertebra, at the lower border of which it terminates in the thoracic aorta. The arch thus formed has its convexity upwards and to the right; in its concavity are situated the left bronchus and the right pulmonary artery. According to its direction, it is somewhat arbitrarily divided into an ascending, transverse, and descending part. Morphologically, the ascending

Fig. 321.—The Arch of the Aorta, with the Pulmonary Artery and Chief Branches of the Aorta.

(From a dissection in St. Bartholomew's Hospital Museum.)


RIGHT RECURRENT LARYNGEAL NERVE
Transverse cervical artery
Right common carotid artery
Suprascapular artery
Internal jugular vein
PNEUMOGASTRIC NERVE
Subclavian vein
Inferior thyroid vein
PHRENIC NERVE
Left innominate vein
Ascending aorta
Superior vena cava
RIGHT BRONCHUS
Branch to superior lobe of lung
Upper branch of right pulmonary artery
Branch to middle lobe of lung
Right pulmonary vein
RIGHT AURICLE
Right coronary artery
Lower branch of right pulmonary artery
THORACIC VERTEBRA
Intercostal vein
Intercostal artery
Vena azygos major
Intercostal vein
Intercostal artery
Intercostal vein
Intercostal artery
THYROID BODY
LEFT RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
Left internal jugular vein
Left common carotid artery
Left subclavian artery
Left subclavian vein
TRACHEA
Inferior thyroid vein
PHRENIC NERVE (hooked aside)
RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
DUCTUS ARTERIOSUS
Left pulmonary artery
Pulmonary artery
Right pulmonary artery
LEFT BRONCHUS
Left coronary artery
Upper left pulmonary vein
RIGHT VENTRICLE (Conus arteriosus)
Lower left pulmonary artery
Lower left pulmonary vein
ŒSOPHAGUS (hooked aside)
THORACIC DUCT
Thoracic aorta

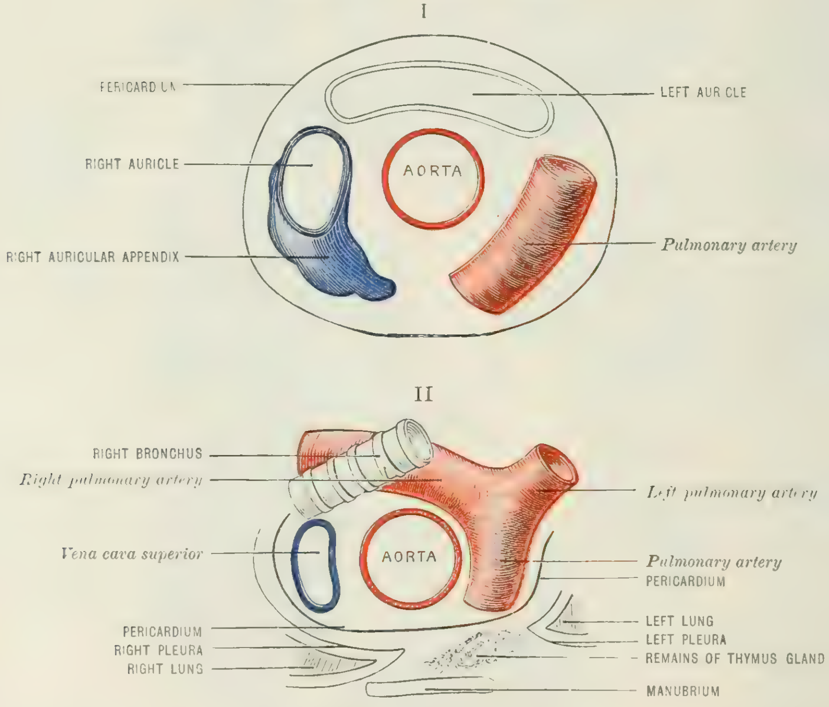
portion is the ventral aorta; the descending portion, part of the left dorsal aorta; and the transverse portion, the fourth left aortic arch. Each portion requires a separate description.

The Ascending Portion of the Arch of the Aorta

The ascending portion or ventral aorta ascends behind the sternum from the upper part of the left ventricle of the heart, on a level with the lower border of the third left costal cartilage, to the upper border of the second right costal cartilage at the junction of these cartilages with the sternum. It measures from two to two and a quarter inches (5·5 cm.), forming, as it ascends, a gentle curve, the most prominent part of which, when the aorta is distended, is situated about a quarter of an inch (6 mm.) from the sternum. It is enclosed for the greater part of its length in the pericardium, being invested, together with the pulmonary artery, in a common sheath formed by the serous layer of that membrane. A dilatation known as the great sinus of the arch of the aorta is often present along the right side. Immediately above the heart the aorta presents three bulgings, known as the sinuses of Valsalva; they are placed, two anteriorly, and one posteriorly. From the anterior are derived the coronary arteries of the heart. (See Heart.)

Fig. 322.—Scheme of the Relations of the First Portion of the Arch of the Aorta. (Walsham.)

I, at origin: II, a little higher up.


I
PERICARDIUM
LEFT AURICLE
RIGHT AURICLE
AORTA
RIGHT AURICULAR APPENDIX
Pulmonary artery
II
RIGHT BRONCHUS
Right pulmonary artery
Left pulmonary artery
Vena cava superior
AORTA
Pulmonary artery
PERICARDIUM
LEFT LUNG
LEFT PLEURA
PERICARDIUM
RIGHT PLEURA
REMAINS OF THYMUS GLAND
RIGHT LUNG
MANUBRIUM

Relations.—In front (fig. 322), it is overlapped at its commencement by the right auricular appendix and the pulmonary artery. Higher up, as the pulmonary artery and auricular appendix diverge, it is separated from the manubrium by the pericardium, the remains of the thymus gland, and by the loose tissue and fat in the superior mediastinum, and is here slightly overlapped by the right pleura and by the edge of the right lung in full inspiration. The commencement of the coronary arteries is also in front.

Behind are the left auricle of the heart, the right pulmonary artery, the right bronchus, and the anterior right deep cardiac nerves.

On the **right side** it is in contact, below with the right auricle, and above with the superior vena cava.

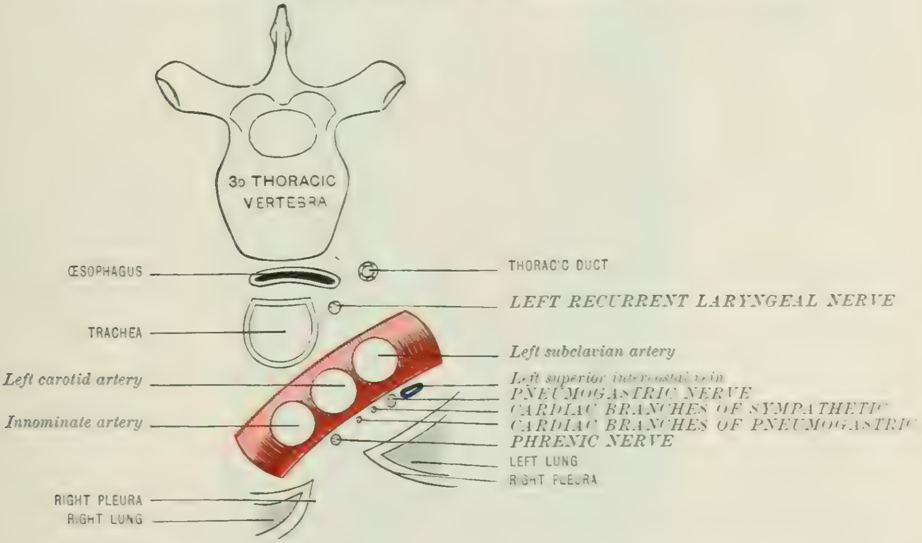
On the **left side** are the pulmonary artery and the branches of the right superficial cardiac nerves.

THE TRANSVERSE PORTION OF THE ARCH OF THE AORTA

The transverse portion of the arch of the aorta extends in a gentle curve upwards, backwards, and to the left, from the level of the upper border of the second right costal cartilage to the left side of the body of the fourth thoracic vertebra. Passing under the arch are the left bronchus, the right pulmonary artery, and the left recurrent laryngeal nerve. It measures about one inch and four-fifths (4·5 cm.).

Relations.—In front (fig. 323), it is slightly overlapped by the right pleura and lung, and to a greater extent by the left pleura and lung. It is crossed in the following order from right to left, by the phrenic nerve, by the cardiac branches of the pneumogastric nerve, the cardiac branches of the sympathetic nerve, by the pneumogastric nerve, and by the left superior intercostal vein as it passes up to the left innominate vein.

FIG. 323.—SCHEME OF THE RELATIONS OF THE TRANSVERSE PORTION OF THE ARCH OF THE AORTA. (Walsham.)


3D THORACIC VERTEBRA
ŒSOPHAGUS
THORACIC DUCT
LEFT RECURRENT LARYNGEAL NERVE
TRACHEA
Left subclavian artery
Left carotid artery
Left superior intercostal vein
PNEUMOGASTRIC NERVE
CARDIAC BRANCHES OF SYMPATHETIC
Innominate artery
CARDIAC BRANCHES OF PNEUMOGASTRIC
PHRENIC NERVE
LEFT LUNG
RIGHT PLEURA
RIGHT PLEURA
RIGHT LUNG

Behind it (fig. 323) are the trachea, the œsophagus, the thoracic duct, the deep cardiac plexus which is situated on the trachea just above its bifurcation, and the left recurrent laryngeal nerve.

Above it (fig. 321) are the three chief branches for the head, neck, and upper extremities, namely, the innominate, the left carotid and the left subclavian arteries, and the left innominate vein.

Below it—that is, in its concavity—are the bifurcation of the pulmonary artery, the left bronchus, the left recurrent laryngeal nerve, the remains of the ductus arteriosus, the superficial cardiac plexus, two or more bronchial lymphatic glands (fig. 321), and the reflexion of the pericardium.

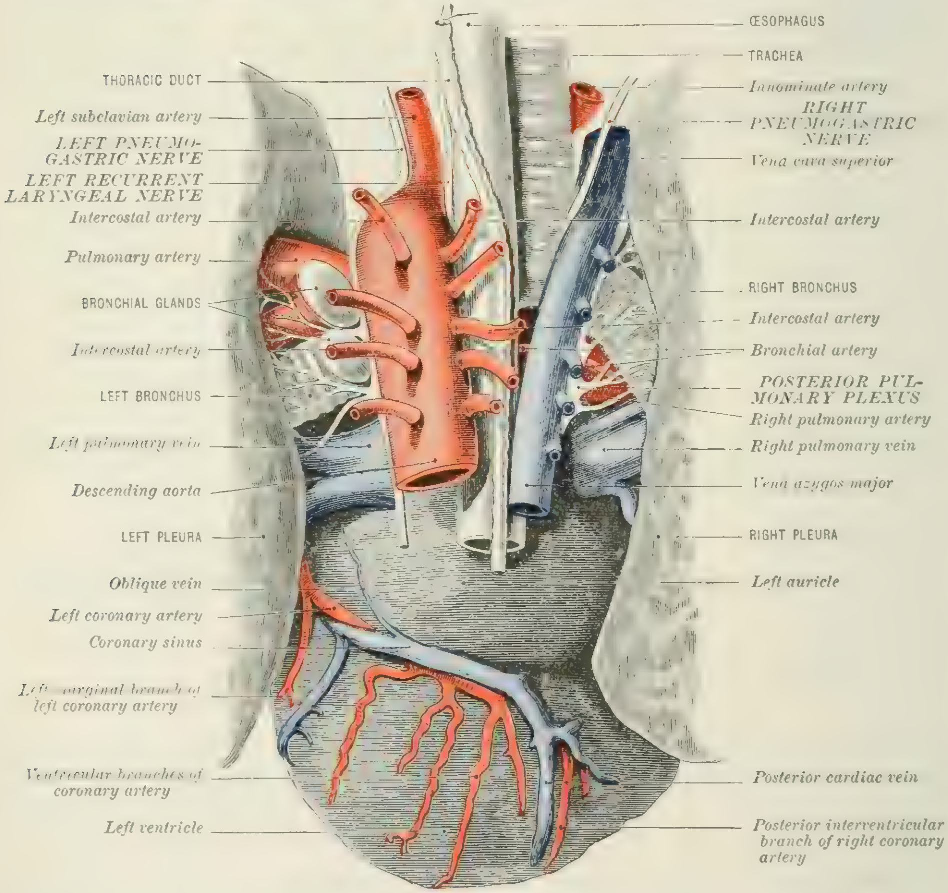
The Descending Portion of the Arch of the Aorta

The descending portion of the arch of the aorta, morphologically a part of the primitive dorsal aorta, descends by the left side of the body of the fourth and fifth thoracic vertebræ, and ends at the lower border of the latter in the thoracic aorta.

Just below the spot where the ductus arteriosus (the fifth left arch) joins the aorta, a constriction (the **aortic isthmus**) is at times met with, and below this again a dilatation of a fusiform shape (the **aortic spindle**).

Relations.—In front, it is in contact with the reflexion of the left pleura and the root of the left lung (fig. 325).

Fig. 324.—The Heart and Great Vessels, with the Root of the Lungs, seen from behind. (St. Bartholomew's Hospital Museum.)


ŒSOPHAGUS
TRACHEA
THORACIC DUCT
Innominate artery
Left subclavian artery
RIGHT PNEUMOGASTRIC NERVE
LEFT PNEUMOGASTRIC NERVE
Vena cava superior
LEFT RECURRENT LARYNGEAL NERVE
Intercostal artery
Intercostal artery
Pulmonary artery
RIGHT BRONCHUS
BRONCHIAL GLANDS
Intercostal artery
Intercostal artery
Bronchial artery
POSTERIOR PULMONARY PLEXUS
LEFT BRONCHUS
Right pulmonary artery
Left pulmonary vein
Right pulmonary vein
Vena azygos major
Descending aorta
LEFT PLEURA
RIGHT PLEURA
Oblique vein
Left auricle
Left coronary artery
Coronary sinus
Left marginal branch of left coronary artery
Ventricular branches of coronary artery
Posterior cardiac vein
Left ventricle
Posterior interventricular branch of right coronary artery

Behind, it is in relation with the left side of the bodies of the fourth and fifth thoracic vertebræ and the pleura.

To the **right side** are the œsophagus and thoracic duct, and the fourth and fifth thoracic vertebræ.

To the **left side** are the left pleura and lung.

Variations in the Arch of the Aorta

The variations that have been met with in the aortic arch are very numerous. Only the chief can be here mentioned. They may be divided into:—1. **Variations in the arch itself**; and 2. **Variations in the number and arrangement of the three chief branches.** The variations in the coronary arteries are described under Coronary Arteries, page 473.

(1) *Variations in the Aortic Arch itself*

The variations in the aortic arch itself may for the most part be traced to abnormalities in development of the embryonic structures from which the three portions of the arch and the pulmonary arteries and ductus arteriosus are derived, i.e. (*a*) the primitive ventral aortic stem; (*b*) the fourth and fifth branchial arches; and (*c*) the dorsal aortic stems.

(*a*) *Variations depending on Abnormalities in Development of the Ventral Aortic Stem*

These variations are closely associated with abnormalities of the pulmonary artery and heart. They depend upon deficient development of the septum which normally divides the anterior stem into the first portion of the aorta and the pulmonary artery. The following are some of the chief variations:—

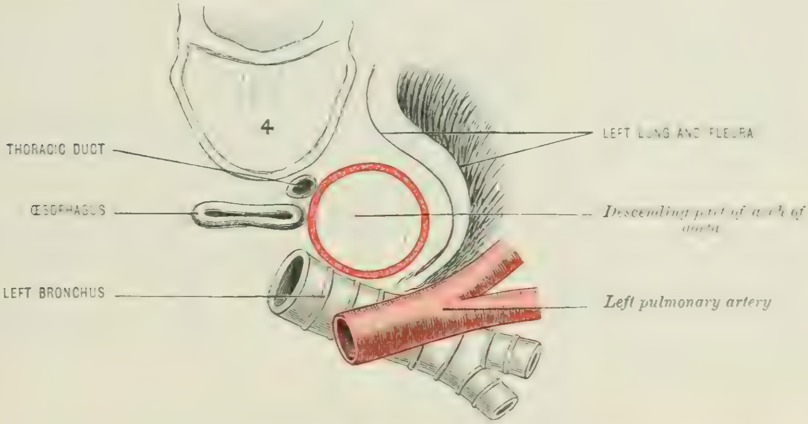
(1) The aorta and pulmonary artery may arise as a single stem from a simple heart. The septum here is completely absent. The condition resembles the normal state in fishes.

(2) The aorta and pulmonary artery may be more or less conjoined, and the septum of the heart incomplete. This is analogous to the normal condition in reptiles.

(3) The aorta and pulmonary artery may be transposed.

(4) The aorta or pulmonary artery may be in part obliterated, and the blood carried into the remainder of the affected vessel through an abnormal opening beyond the obliterated part.

FIG. 325.—SCHEME OF THE RELATIONS OF THE THIRD PORTION OF THE ARCH OF THE AORTA. (Walsham.)



(*b*) *Variations depending on Abnormalities in Development of the Fourth and Fifth Aortic or Branchial Arches*

(1) The aorta may be double, the normal condition in amphibians, each arch giving off a corresponding carotid and subclavian artery. This abnormality is explained by the persistence of the right fourth aortic arch and right descending aortic stem, as well as the corresponding parts on the left side. The trachea and œsophagus pass through the arterial circle thus formed.

(2) The aortic arch may turn over the right bronchus instead of over the left. This is the normal condition in birds, and is explained by the persistence of the right fourth aortic arch and right descending aortic stem and the obliteration of the corresponding parts on the left side.

(3) The pulmonary artery may be given off from the aorta. This condition is due to the obliteration of the anterior part of the fifth branchial arch and the persistence of the posterior part which normally constitutes the ductus arteriosus.

(*c*) *Variations depending on Abnormalities in Development of the Dorsal Aortic Stems*

The right subclavian may arise from the third part of the arch of the aorta. It then passes behind the trachea and œsophagus, and in front of the vertebral column, to gain the interval between the right scalene muscles. The explanation of this abnormality is that the right fourth arch, from which the right subclavian is normally developed, is obliterated, whilst the right posterior aortic stem remains pervious as far as the spot where it normally joins the right fourth arch, the blood thus passing through the aortic stem instead of the arch. The recurrent laryngeal nerve in these cases runs straight to the larynx, since, the fourth arch being obliterated, the nerve is no longer hooked down by it. Rudiments of the right aortic stem frequently persist as the aberrans branch of the superior intercostal artery and thoracic aorta.

In addition to the above variations, the arch of the aorta may be higher or lower in the thorax than normal. In the former case it may cross the first bone of the sternum, just below, or even a little above, the sternal notch, and reach the side of the second or third thoracic vertebra instead of the fourth. In the latter case, that is, when it is situated lower in the thorax than normal, it may cross the sternum below the level of the manubrium, and come into contact with the spine on a level with the fifth or sixth thoracic vertebra.

2. *The Chief Variations in the Three Primary Branches of the Transverse Portions of the Aortic Arch*

(1) All may arise from a **common stem**: a condition explained on the supposition that the anterior aortic roots have become fused, and have so collected all the branches together. A similar condition is normal in the horse. This variation is rare.

(2) They may arise as **two stems**: (*a*) One stem may be common to the right subclavian, right carotid, and left carotid, the other stem being the left subclavian. This is one of the commonest variations in the arrangement of the primary branches. It is the normal condition in many mammals, and was formerly described as the normal condition in man. It is of some surgical interest, in that the left carotid when thus given off may cross in front of the trachea. (*b*) One stem may be common to the left subclavian, left carotid, and right carotid, the other stem being the right subclavian. In this variety the right carotid passes in front of the trachea. (*c*) There may be two innominate arteries, one stem forming the right, the other a left innominate artery as in birds. (*d*) One stem may be common to the right and left carotid arteries, the other stem being the left subclavian—the right subclavian in this case coming from the thoracic aorta.

(3) They may arise as **three stems**: but, in place of being given off in the normal way, (*a*) the right and left subclavian may come off separately, and the carotids arise by a common stem between the subclavians. This is the normal condition in some cetaceans. (*b*) The right subclavian and right carotid may arise separately, the left carotid and left subclavian forming a left innominate stem. (*c*) The innominate may give off the left carotid, the left vertebral, and left subclavian, the other two vessels arising from the arch.

(4) They may arise as **four stems**, which may be given off in the following order: (*a*) innominate, left carotid, left vertebral, left subclavian (the commonest condition); (*b*) right carotid, left carotid, left subclavian, right subclavian; (*c*) right subclavian, right carotid, left carotid, left subclavian—the normal condition in the walrus and wombat.

(5) They may arise as **five stems**, the five branches being given off in the following order: (*a*) right subclavian, right carotid, left carotid, left vertebral, left subclavian; (*b*) right carotid, left carotid, left vertebral, left subclavian, right subclavian; (*c*) right carotid, left carotid, left subclavian, left vertebral, right subclavian; (*d*) right subclavian, right external carotid, right internal carotid, left common carotid, left subclavian; (*e*) innominate, right vertebral, left carotid, left vertebral, left subclavian.

(6) They may arise as **six stems**, given off as follows: right subclavian, right vertebral, right carotid, left carotid, left vertebral, left subclavian.

BRANCHES OF THE ARCH OF THE AORTA

1. The **ascending portion** gives off—(1) Right coronary; (2) left coronary.
2. The **transverse portion** gives off—(1) Innominate; (2) left common carotid; (3) left subclavian.
3. The **descending portion** gives off no branch.

I. The branches of the first, or ascending, portion of the arch of the aorta are the **right** and **left coronary** for the supply of the tissues of the heart. They come off from the aorta, immediately above the aortic valves, from two of the dilatations known as the sinuses of Valsalva.

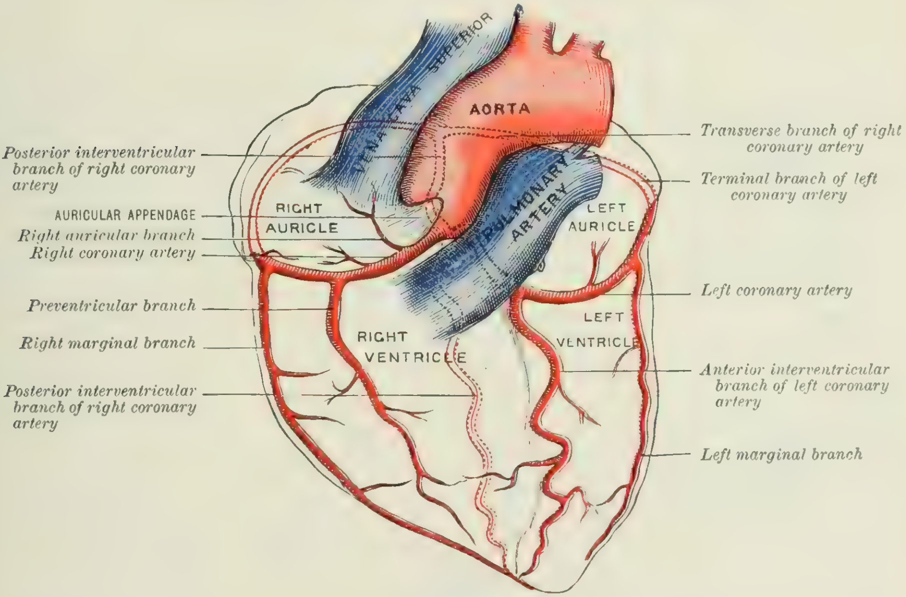
THE RIGHT CORONARY ARTERY

The **right coronary artery** (figs. 321 and 326) arises from the right anterior sinus of Valsalva, and, passing forwards and to the right between the right auricular appendix and the pulmonary artery, turns to the right, and courses in the right auriculo-ventricular groove to the back of the heart, where it follows the posterior interventricular groove to the apex of the ventricles, giving off, however, a small transverse branch, which continues in the groove between the left auricle and ventricle to anastomose with the terminal branch of the left coronary artery. In this course it gives off the following branches: (*a*) A **right auricular branch** (fig. 326), which turns backwards and upwards between the right auricle and the aorta, supplying the structures between which it runs and the auricular septum; (*b*) a **preventricular branch** (fig. 326), which runs down the front of the right ventricle, supplying its walls; (*c*) a **right marginal branch** (fig. 326), which courses down the right margin of the right ventricle; (*d*) a **posterior interventricular branch,** or the continuation of the coronary trunk, which passes down the posterior interventricular groove, giving twigs to each ventricle and the interventricular septum, and anastomosing at the apex of the heart with the anterior interventricular branch of the left coronary artery; and (*e*) the **transverse branch,** which runs in the left auriculo-ventricular groove to anastomose with the terminal branch of the left coronary (fig. 326).

THE LEFT CORONARY ARTERY

The **left coronary artery** (figs. 321 and 326), a little larger than the right, arises from the left anterior sinus of Valsalva, and, passing forwards and to the left between the pulmonary artery and left auricular appendix, courses round the heart in the left auriculo-ventricular groove to anastomose with the transverse branch of the right coronary artery. It gives off the following branches: (*a*) A **left auricular branch,** which supplies the left auricle, the pulmonary artery, and the commencement of the aorta. (*b*) A **large anterior interventricular branch,** which is larger than the continuation of the vessel between the auricle and ventricle, and is regarded by some as the main trunk of the left coronary artery. It courses downwards in the anterior interventricular groove to the apex of the heart, where it forms a slight anastomosis with the posterior interventricular branch of the right vessel (fig. 324). It supplies both ventricles and the interventricular septum. (*c*) A **left marginal branch,** which runs down the left margin of the heart, supplying branches to the walls of the ventricle. (*d*) The **terminal branch,** the continuation of the vessel, anastomoses with the transverse branch of the right coronary artery.

FIG. 326.—SCHEME OF THE CORONARY ARTERIES. (Walsham.)


VENA CAVA SUPERIOR
AORTA
PULMONARY ARTERY
RIGHT AURICLE
LEFT AURICLE
RIGHT VENTRICLE
LEFT VENTRICLE
Posterior interventricular branch of right coronary artery
AURICULAR APPENDAGE
Right auricular branch
Right coronary artery
Preventricular branch
Right marginal branch
Posterior interventricular branch of right coronary artery
Transverse branch of right coronary artery
Terminal branch of left coronary artery
Left coronary artery
Anterior interventricular branch of left coronary artery
Left marginal branch

Variations in the Coronary Arteries

(*a*) They may arise as a common trunk. (*b*) They may both arise from the same sinus of Valsalva. (*c*) The interventricular and terminal branches of the left coronary may arise separately from the sinus of Valsalva. (*d*) One coronary artery may be larger than usual;

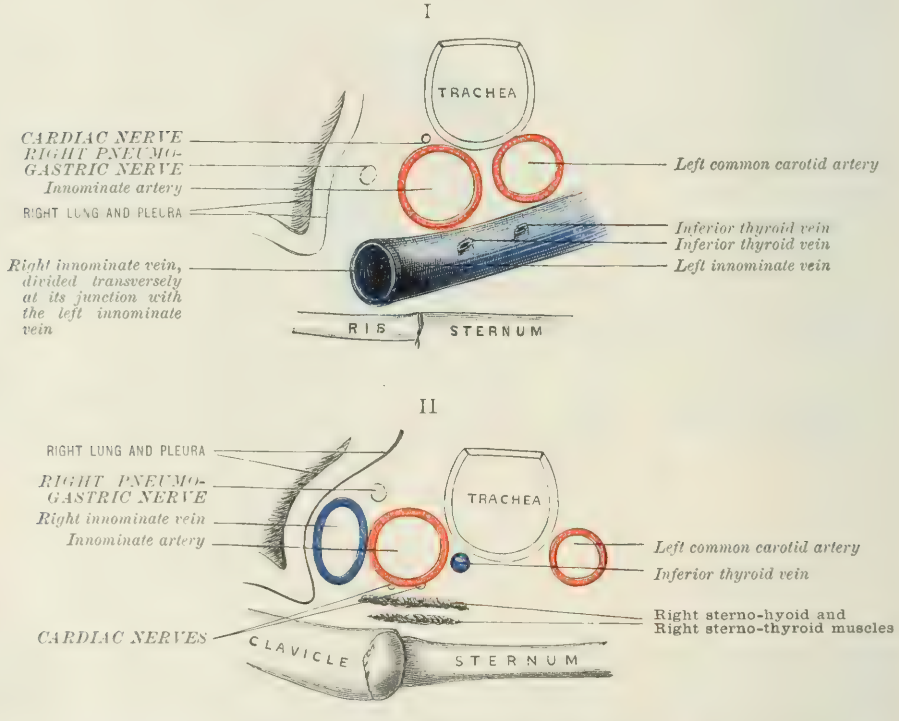
the other vessel is then correspondingly small. (*e*) An extra coronary artery may arise from the pulmonary artery.

II. From the transverse part of the aortic arch are given off the **innominate,** the **left common carotid,** and the **left subclavian arteries.** The innominate and left carotid arise close together—indeed, so close that, when seen from the interior of the aorta, the orifices appear merely separated by a thin septum. The left subclavian arises a little less close to the left carotid.

THE INNOMINATE ARTERY

The **innominate** or **brachio-cephalic artery** (fig. 321), the largest branch of the arch of the aorta, extends from near the commencement of the transverse portion, upwards and a little forwards and to the right, as high as the upper limit of the right sterno-clavicular joint where it bifurcates into the right common carotid and right subclavian arteries. It lies obliquely in front of the trachea, and measures from an inch and a half to two inches in length (about 4 cm.).

Fig. 327.—Scheme of the Relations of the Innominate Artery. (Walsham.)
I, a little above origin ; II, a little below bifurcation.


I
TRACHEA
CARDIAC NERVE
RIGHT PNEUMO-GASTRIC NERVE
Innominate artery
RIGHT LUNG AND PLEURA
Right innominate vein, divided transversely at its junction with the left innominate vein
Left common carotid artery
Inferior thyroid vein
Inferior thyroid vein
Left innominate vein
RIB
STERNUM
II
RIGHT LUNG AND PLEURA
RIGHT PNEUMO-GASTRIC NERVE
Right innominate vein
Innominate artery
TRACHEA
Left common carotid artery
Inferior thyroid vein
Right sterno-hyoid and Right sterno-thyroid muscles
CARDIAC NERVES
CLAVICLE
STERNUM

Relations.—**In front** of the artery (fig. 327) are the manubrium, the origins of the sterno-hyoid and sterno-thyroid muscles, the right sterno-clavicular joint and the remains of the thymus gland. The left innominate vein crosses the root of the vessel, and the inferior thyroid veins descend obliquely over it to end in the left innominate vein. The inferior cervical cardiac branches of the right pneumogastric pass in front of it on their way to the deep cardiac plexus.

Behind, it lies on the trachea, crossing that tube obliquely from left to right, and coming into contact above with the right pleura.

To the **right side** are the right innominate vein, the right pneumogastric nerve, and the pleura.

To the **left side** are the left common carotid, the remains of the thymus gland, the inferior thyroid veins; and higher, the trachea.

Variations in the Innominate Artery

The **variations in the innominate artery** are of surgical interest. (*a*) It may divide lower than normal, thus decreasing the available space for the application of a ligature to it, but at the same time increasing the length of the first portion of the right subclavian artery. (*b*) It may divide higher than usual, and may then incline abnormally to the left, mounting in front of the trachea above the sternum. Under these circumstances it is in danger in the low operation of tracheotomy. (*c*) When abnormally long and inclining to the left, it may pass behind the trachea or the œsophagus to gain the right side. (*d*) It may give off the thyroidea ima artery, and, more rarely the vertebral, the internal mammary or a smaller twig, as a bronchial, thymic, pericardiac, or tracheal branch.

The **branches of the innominate artery** are: (1) The right common carotid; and (2) the right subclavian. These are terminal branches. There are usually no collateral branches from this vessel, but at times the **thyroidea ima** may arise from it.

THE COMMON CAROTID ARTERIES

The **common carotid arteries** pass up deeply from the thorax on either side of the neck to about the level of the upper border of the thyroid cartilage, where they divide into the external and internal carotid arteries. The **external carotid** supplies the structures at the upper part of the front and side of the neck, the larynx, pharynx, tongue, face, the upper part of the back of the neck, the structures in the pterygoid region, the scalp, and in chief part the membranes of the brain. The **internal carotid** gives off no branch in the neck, but enters the cranium and supplies the greater part of the brain, the structures contained in the orbit, and portions of the membranes of the brain.

The common carotid artery on the right side arises from the bifurcation of the innominate behind the sterno-clavicular joint; on the left side from the arch of the aorta a little to the left of the innominate artery, and on a somewhat posterior plane to that vessel (fig. 321). The portion of the left common carotid artery which extends from the arch of the aorta to the level of the sterno-clavicular articulation lies deeply in the chest, and requires a separate description; but above the level of the sterno-clavicular joint the relations of the right and left carotids are practically the same, and are given under the account of the right common carotid.

THORACIC PORTION OF THE LEFT COMMON CAROTID ARTERY

Within the thorax the left common carotid is deeply placed behind the first bone of the sternum, and is overlapped by the left lung and pleura. It arises from the middle of the transverse portion of the aortic arch, close to the left side of the innominate artery, and a little posterior to that vessel, and ascends obliquely in front of the trachea to the left sterno-clavicular articulation, above which its relations are similar to those of the right common carotid.

Relations.—In front, but at some little distance, are the manubrium and the origins of the left sterno-hyoid and sterno-thyroid muscles; whilst in contact with it are the remains of the thymus gland, and the loose connective tissue and fat of the superior mediastinum. Crossing its root is the left innominate vein.

Behind, it lies successively upon the trachea, the œsophagus (which here inclines a little to the left), the thoracic duct, and the left recurrent laryngeal nerve.

To its **right side** is the root of the innominate artery, and higher up are the trachea and the inferior thyroid veins.

To its **left side,** but on a posterior plane, are the left subclavian artery and the left pneumogastric nerve; and, slightly overlapping it, the edge of the left pleura and lung (fig. 328).

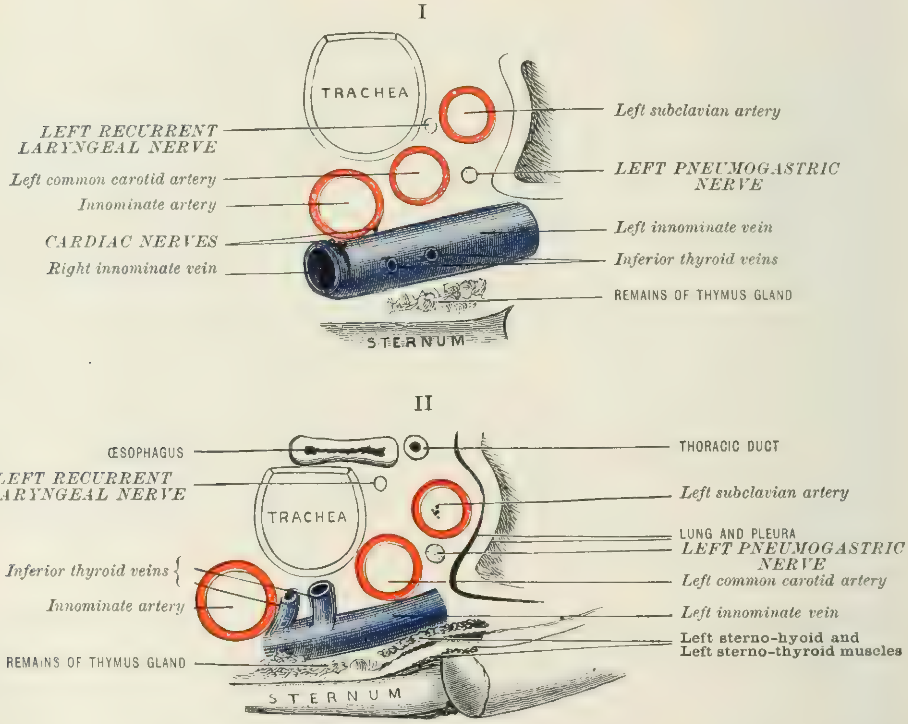
The variations in the origin of the left common carotid are given under VARIATIONS OF THE ARCH OF THE AORTA (page 471).

THE COMMON CAROTID ARTERY IN THE NECK

The **common carotid artery in the neck** extends from the sterno-clavicular articulation to the upper border of the thyroid cartilage on a level with the fourth cervical vertebra where it divides into the external and internal carotid arteries. A line drawn from the sterno-clavicular joint to the interval between the mastoid process and the angle of the jaw would indicate its course. The artery is at first deeply placed beneath the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, and at the level of the top of the sternum is only three-quarters of an inch (2 cm.) distant from its fellow of the opposite side, and merely separated from it by the trachea. As the carotid arteries run up the neck, however, they diverge in the form of a V and become more superficial, though on a plane posterior to that in which they lie at the root of the neck, and are separated from each other by the larynx and pharynx. At their bifurcation they are about two inches and a quarter (6 cm.) apart. The common carotid is contained in a sheath of fascia common to it and the internal jugular vein and pneumogastric nerve. The artery, vein, and nerve, however, are not in contact, but separated from one another by fibrous septa, which divide the common sheath into three compartments: one for the artery, one for the vein, and one for the nerve. The vein, which is larger than the artery, lies to the outer side, and somewhat overlaps the artery. The pneumo-

FIG. 328.—SCHEME OF THE RELATIONS OF THE LEFT COMMON CAROTID AND LEFT SUBCLAVIAN ARTERIES WITHIN THE THORAX. (Walsham.)

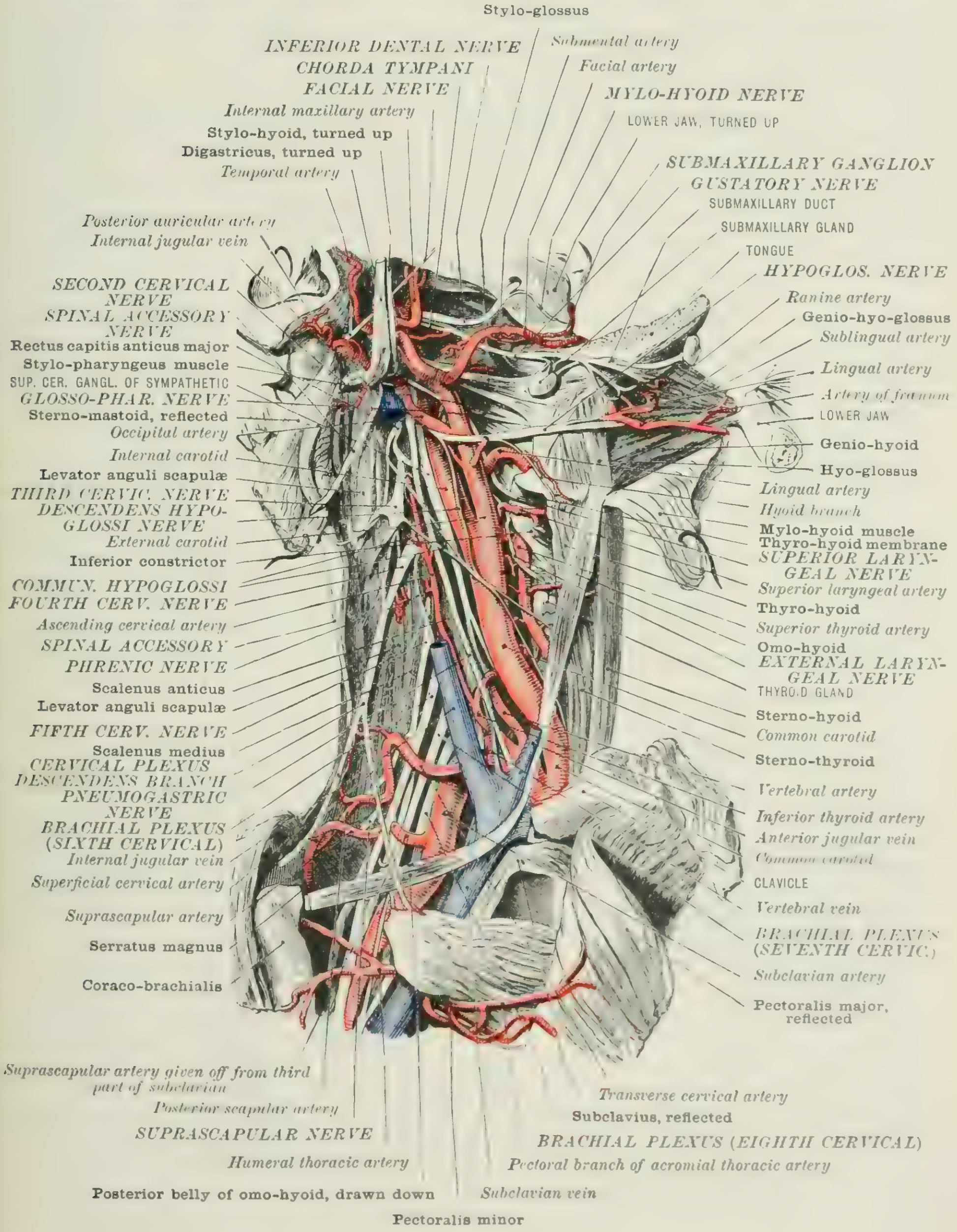
I, just above origin; II, just below level of sterno-clavicular joint.


I
TRACHEA
LEFT RECURRENT LARYNGEAL NERVE
Left common carotid artery
Innominate artery
CARDIAC NERVES
Right innominate vein
Left subclavian artery
LEFT PNEUMOGASTRIC NERVE
Left innominate vein
Inferior thyroid veins
REMAINS OF THYMUS GLAND
STERNUM
II
ŒSOPHAGUS
LEFT RECURRENT LARYNGEAL NERVE
TRACHEA
Inferior thyroid veins
Innominate artery
REMAINS OF THYMUS GLAND
STERNUM
THORACIC DUCT
Left subclavian artery
LUNG AND PLEURA
LEFT PNEUMOGASTRIC NERVE
Left common carotid artery
Left innominate vein
Left sterno-hyoid and Left sterno-thyroid muscles

gastric nerve lies behind and between the two vessels. The artery on the right side measures about three and three-quarter inches (9·5 cm.); on the left side about four and three-quarter inches (12 cm.).

Fig. 329.—The Common Carotid, the External and Internal Carotid and the Subclavian Arteries of the Right Side and their Branches.

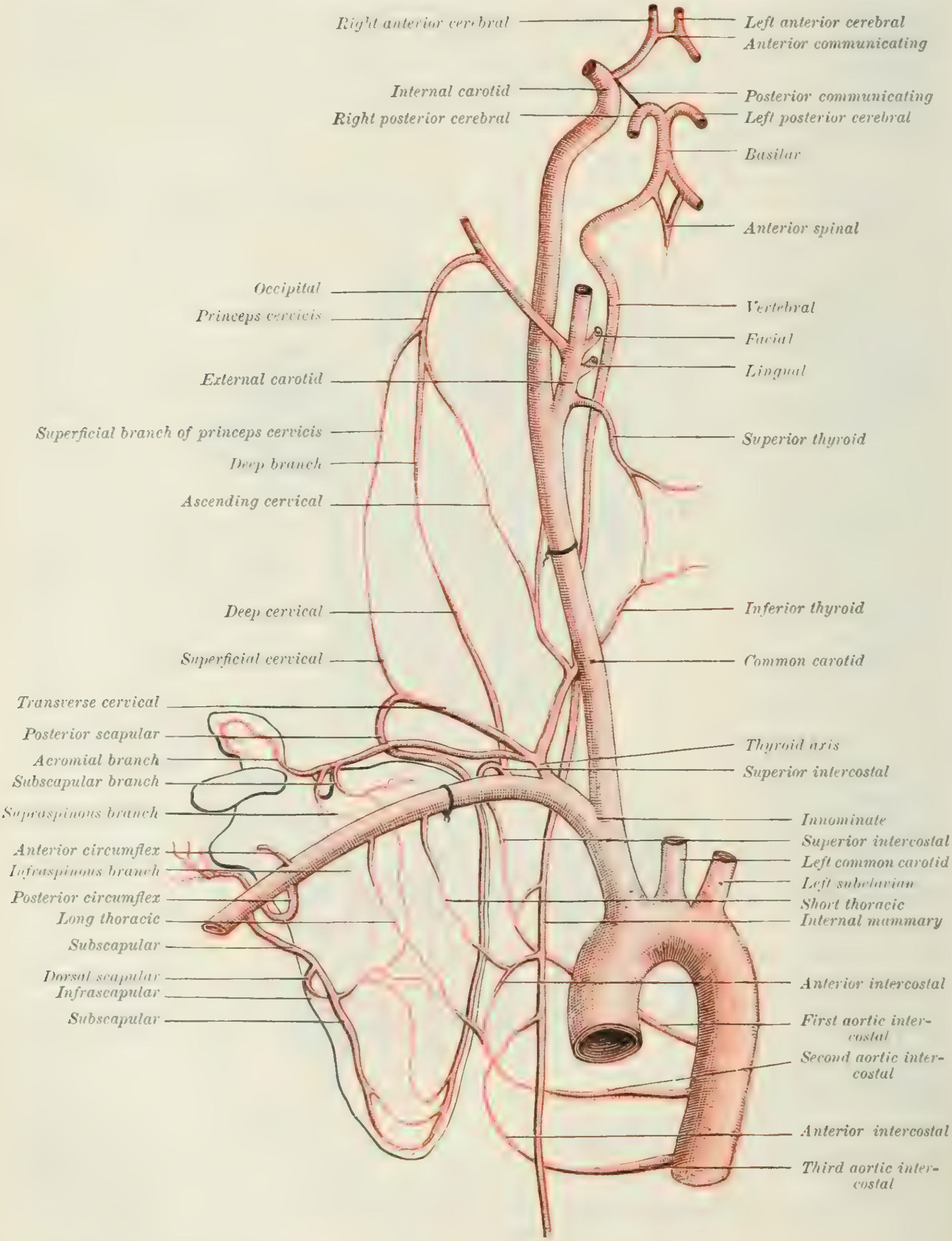
(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)


Stylo-glossus
INFERIOR DENTAL NERVE
CHORDA TYMPANI
FACIAL NERVE
Internal maxillary artery
Stylo-hyoid, turned up
Digastricus, turned up
Temporal artery
Submental artery
Facial artery
MYLO-HYOID NERVE
LOWER JAW, TURNED UP
SUBMAXILLARY GANGLION
GUSTATORY NERVE
SUBMAXILLARY DUCT
SUBMAXILLARY GLAND
TONGUE
HYPOGLOS. NERVE
Posterior auricular artery
Internal jugular vein
SECOND CERVICAL NERVE
SPINAL ACCESSORY NERVE
Rectus capitis anticus major
Stylo-pharyngeus muscle
SUP. CER. GANGL. OF SYMPATHETIC
GLOSSO-PHAR. NERVE
Sterno-mastoid, reflected
Occipital artery
Internal carotid
Levator anguli scapulæ
THIRD CERVIC. NERVE
DESCENDENS HYPOGLOSSI NERVE
External carotid
Inferior constrictor
COMMUN. HYPOGLOSSI
FOURTH CERV. NERVE
Ascending cervical artery
SPINAL ACCESSORY
PHRENIC NERVE
Scalenus anticus
Levator anguli scapulæ
FIFTH CERV. NERVE
Scalenus medius
CERVICAL PLEXUS
DESCENDENS BRANCH
PNEUMOGASTRIC NERVE
BRACHIAL PLEXUS (SIXTH CERVICAL)
Internal jugular vein
Superficial cervical artery
Suprascapular artery
Serratus magnus
Coraco-brachialis
Ranine artery
Genio-hyo-glossus
Sublingual artery
Lingual artery
Artery of frænum
LOWER JAW
Genio-hyoid
Hyo-glossus
Lingual artery
Hyoid branch
Mylo-hyoid muscle
Thyro-hyoid membrane
SUPERIOR LARYNGEAL NERVE
Superior laryngeal artery
Thyro-hyoid
Superior thyroid artery
Omo-hyoid
EXTERNAL LARYNGEAL NERVE
THYROID GLAND
Sterno-hyoid
Common carotid
Sterno-thyroid
Vertebral artery
Inferior thyroid artery
Anterior jugular vein
Common carotid
CLAVICLE
Vertebral vein
BRACHIAL PLEXUS (SEVENTH CERVIC.)
Subclavian artery
Pectoralis major, reflected
Suprascapular artery given off from third part of subclavian
Posterior scapular artery
SUPRASCAPULAR NERVE
Humeral thoracic artery
Posterior belly of omo-hyoid, drawn down
Pectoralis minor
Transverse cervical artery
Subclavius, reflected
BRACHIAL PLEXUS (EIGHTH CERVICAL)
Pectoral branch of acromial thoracic artery
Subclavian vein

Relations.—In front the artery is covered by the skin, superficial fascia, platysma, and deep fascia, and is more or less overlapped by the sterno-mastoid muscle. At the lower part of the neck it is covered in addition by the sterno-hyoid and sterno-thyroid muscles, and is crossed by the anterior jugular vein, and is often overlapped by the thyroid body. Opposite the cricoid cartilage it is crossed obliquely by the omo-hyoid muscle; and above this spot by the middle and superior thyroid, the lingual, and generally the facial veins in their course to the internal jugular, and by the middle sterno-mastoid artery as it passes from the superior thyroid artery, its usual source, on its way down to the sterno-mastoid muscle. Along the anterior

FIG. 330.—THE COLLATERAL CIRCULATION AFTER LIGATURE OF THE COMMON CAROTID AND SUBCLAVIAN ARTERIES.

(A ligature is placed on the common carotid and on the third portion of the subclavian artery.)


Right anterior cerebral
Internal carotid
Right posterior cerebral
Occipital
Princeps cervicis
External carotid
Superficial branch of princeps cervicis
Deep branch
Ascending cervical
Deep cervical
Superficial cervical
Transverse cervical
Posterior scapular
Acromial branch
Subscapular branch
Supraspinous branch
Anterior circumflex
Infraspinous branch
Posterior circumflex
Long thoracic
Subscapular
Dorsal scapular
Infrascapular
Subscapular
Left anterior cerebral
Anterior communicating
Posterior communicating
Left posterior cerebral
Basilar
Anterior spinal
Vertebral
Facial
Lingual
Superior thyroid
Inferior thyroid
Common carotid
Thyroid axis
Superior intercostal
Innominate
Superior intercostal
Left common carotid
Left subclavian
Short thoracic
Internal mammary
Anterior intercostal
First aortic intercostal
Second aortic intercostal
Anterior intercostal
Third aortic intercostal

border of the sterno-mastoid there is a communicating vein between the facial and anterior jugular veins, which, as it crosses the line of the carotid artery, is in danger of being wounded in the operation of tying the carotid. The descendens hypoglossi nerve generally descends in front of the carotid sheath, being there joined by the communicantes hypoglossi, one or two small branches of the second and third cervical nerves. At times this nerve runs within the sheath. There are usually two lymphatic glands about the bifurcation of the artery. These are often found enlarged and infiltrated in cancer of the lip and tongue.

Behind, the common carotid lies on the longus colli and scalenus anticus below, and rectus capitis anticus major above. Posterior to the artery, but in the same sheath, is the pneumogastric nerve; and posterior to the sheath, the chain of the sympathetic and the cervical cardiac branches of the sympathetic and pneumogastric nerves. At the lower part of the neck the inferior thyroid artery courses obliquely behind the carotid, as does likewise the recurrent laryngeal nerve.

Internally, from below upwards, are the trachea and œsophagus, with the recurrent laryngeal nerve in the groove between them, and the terminal branches of the inferior thyroid artery, the lateral lobe of the thyroid body, the cricoid cartilage, the thyroid cartilage, and the lower part of the pharynx. At the angle of bifurcation is a vascular structure known as the **ganglion intercaroticum** or the **carotid gland.**

Externally are the internal jugular vein and the pneumogastric nerve. On the right side, at the root of the neck, the vein diverges somewhat from the artery, leaving a space in which the pneumogastric nerve and vertebral artery are exposed. On the left side the vein approaches and somewhat overlaps the artery, thus leaving no interval corresponding to that on the right side.

The cricoid cartilage is as a rule taken as the centre of the incision in the operation for ligature of the common carotid artery. The incision is made in the line of the vessel parallel to the anterior margin of the sterno-mastoid muscle. The omohyoid forms one of the chief rallying points in the course of the operation for ligature of the artery above that muscle, the usual situation. The artery is found beating at the angle formed by the omo-hyoid with the sterno-mastoid.

Branches.—(1) *External* and (2) *internal carotid arteries.* The common carotid gives off no lateral branch, and consequently does not diminish in size as it runs up the neck. It is often a little swollen just below its bifurcation, a condition that should not be mistaken for an aneurismal dilatation.

Variations of the Common Carotid Arteries

The variations in the origin of the common carotid have been already mentioned under Variations of the Chief Branches of the Aortic Arch (page 472).

The following variations are of surgical interest:—

(A) The artery may cross obliquely the lower part of the trachea above the level of the sternum. This may occur on the **right side**: (*a*) when the innominate is situated abnormally to the left of the middle line; (*b*) when the right common carotid arises as the second branch of the aortic arch; and (*c*) when the right and left common carotids arise as a common stem from the aorta. On the **left side**: when the left common carotid arises from the innominate.

(B) The right common carotid may, when arising from the aorta, run behind the trachea and œsophagus to the right side of the neck.

(C) The commencement of the right common carotid may be above or below the usual spot, according as the innominate bifurcates higher or lower than usual. A low bifurcation of the innominate is somewhat the more common abnormality.

(D) The common carotid may run in a very tortuous manner, forming one or more distinct loops in its course up the neck.

(E) The artery may bifurcate higher or lower than normal. A high bifurcation is the more common. The bifurcation may occur as high as the hyoid bone, or even styloid process; or as low as the cricoid cartilage, or within an inch and a half of its origin.

(F) The artery may not bifurcate, but give off the branches usually derived from the external division as it ascends in the neck.

(G) The common carotid may be absent, the external and internal carotids arising directly from the aorta.

(H) It may give off one or more of the branches usually derived from the external carotid.

(I) It may give off a thyroidea ima.

(J) The pneumogastric nerve may run in front of the artery instead of behind it.

The **collateral circulation** (fig. 330), after ligature of the common carotid, is carried on chiefly by the anastomosis of the internal carotid with the internal carotid of the opposite side through the circle of Willis; by the vertebral with the opposite vertebral; by the inferior thyroid with the superior thyroid; by the deep cervical branch of the superior intercostal with the princeps cervicis of the occipital; by the superior thyroid, lingual, facial, occipital and temporal, with the corresponding arteries of the opposite side, and by the ophthalmic with the angular. The anastomosis between the deep cervical branch of the superior intercostal with the princeps cervicis of the occipital is an important one and is situated deeply at the back of the neck, and is to be found lying between the complexus and semi-spinalis colli muscles.

THE EXTERNAL CAROTID ARTERY

The **external carotid artery,** the smaller of the two branches into which the common carotid divides at the upper border of the thyroid cartilage, is distributed to the anterior part of the neck, the face, and the side of the skull both soft parts and bones, the integuments externally, and dura mater internally. It is developmentally derived from the third aortic arch, and supplies the oral and post-oral visceral branches. It is at first situated internal to the internal carotid; but as it ascends in the neck it forms a gentle curve, with its convexity forwards, and, running slightly backwards as well as upwards, terminates opposite the neck of the lower jaw just below the condyle, by dividing into the internal maxillary and superficial temporal arteries. It here lies superficial to the internal carotid, from which it is separated by a portion of the parotid gland. At its origin it is overlapped by the anterior margin of the sterno-mastoid, and is covered by the superficial fascia, platysma, and deep fascia. Higher up the neck it passes beneath the stylo-hyoid muscle, the posterior belly of the digastric muscle, and the hypoglossal nerve; and, entering the parotid gland, is situated deeply in that structure at its division into its terminal branches. It is separated from the internal carotid artery posteriorly by the stylo-pharyngeus and stylo-glossus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the pneumogastric nerve, a portion of the parotid gland, and the stylo-hyoid ligament; or, if the styloid process is abnormally long, by that process itself. It measures about two and a half inches (6·5 cm.).

Relations (fig. 329).—**In front,** in addition to the skin, superficial fascia, platysma, and deep fascia, it has the hypoglossal nerve, the lingual and facial veins, the posterior belly of the digastricus and stylo-hyoid muscles, the temporo-maxillary vein, the superior cervical lymphatic glands, branches of the facial nerve, and the parotid gland. The sterno-mastoid also overlaps it in the natural state of the parts.

Behind, it is in relation with the internal carotid, from which it is separated by the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the pneumogastric nerve, the stylo-hyoid ligament, and the parotid gland. The superior laryngeal nerve crosses behind both the external and internal carotid arteries.

Internally, it is in relation with the hyoid bone, the pharyngeal wall, the ramus of the jaw, the stylo-maxillary ligament which separates it from the submaxillary gland, and the parotid gland.

Externally, in the first part of its course, it is in contact with the internal carotid artery.

Chief Variations of the External Carotid Artery

The **variations of the external carotid artery** are not of much surgical importance. The variations in its origin have been discussed under VARIATIONS OF THE COMMON CAROTID.

(A) It may be absent, the branches usually derived from it coming off from the upward continuation of the common trunk.

(B) It may run superficial to the stylo-hyoid muscle.

(C) Its branches may come off irregularly; or may be diminished or increased in number either by two or more arising as a common stem, or by its giving origin to branches not usually derived from it, as the sterno-mastoid branch of either the superior thyroid or occipital artery.

(D) At times all its branches come off close together just above its origin.

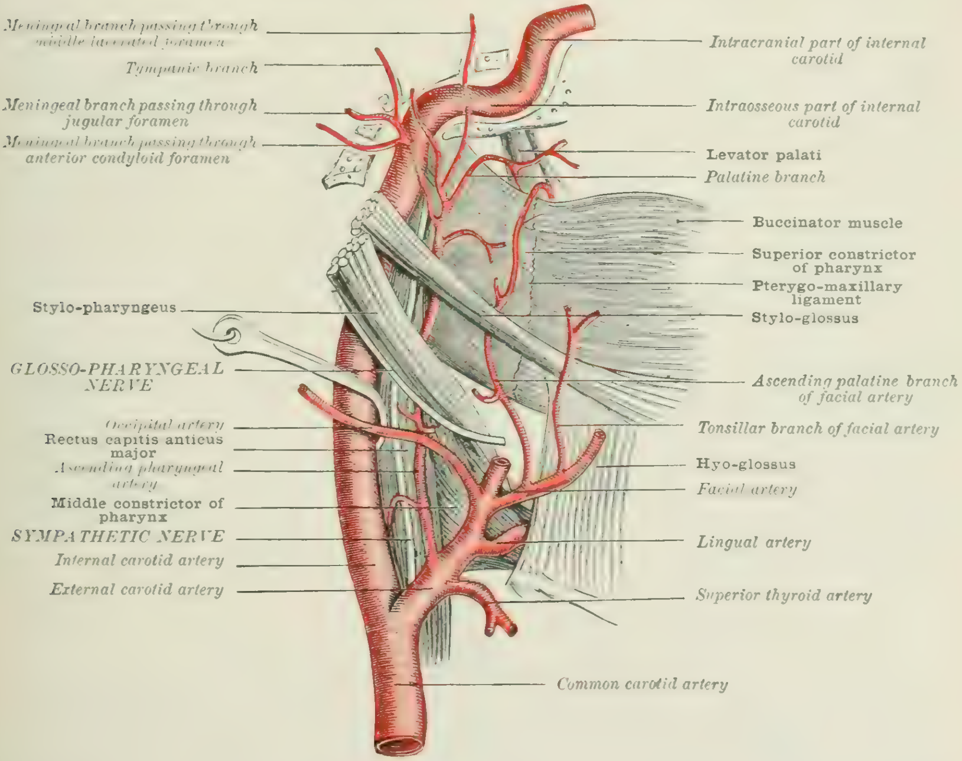
The **branches of the external carotid** are usually given off in the following order, from below upwards:—

1. Ascending pharyngeal	Ascending set.
2. Superior thyroid	Anterior set.
3. Lingual	
4. Facial	
5. Occipital	Posterior set.
6. Posterior auricular	
7. Temporal	Terminal set.
8. Internal maxillary	

1. THE ASCENDING PHARYNGEAL ARTERY

The **ascending pharyngeal artery** is usually the first or second branch of the external carotid. Occasionally it comes off at the bifurcation of the common carotid from the common carotid itself. It is a long slender vessel, the smallest named branch of the external carotid, and runs deeply seated up the neck to the base of the skull, having the walls of the pharynx and the tonsil **internally**, the internal carotid artery **externally**, and the vertebral column, the rectus capitis anticus major, and the sympathetic nerve **posteriorly**. **In front** it is crossed by the stylo-glossus (see fig. 331) and stylo-pharyngeus muscles and the glosso-pharyngeal nerve.

FIG. 331.—SCHEME OF RIGHT ASCENDING PHARYNGEAL ARTERY. (Walsham.)
The internal carotid artery is hooked aside.


Meningeal branch passing through middle lacerated foramen
Tympanic branch
Meningeal branch passing through jugular foramen
Meningeal branch passing through anterior condyloid foramen
Stylo-pharyngeus
GLOSSO-PHARYNGEAL NERVE
Occipital artery
Rectus capitis anticus major
Ascending pharyngeal artery
Middle constrictor of pharynx
SYMPATHETIC NERVE
Internal carotid artery
External carotid artery
Intracranial part of internal carotid
Intraosseous part of internal carotid
Levator palati
Palatine branch
Buccinator muscle
Superior constrictor of pharynx
Pterygo-maxillary ligament
Stylo-glossus
Ascending palatine branch of facial artery
Tonsillar branch of facial artery
Hyo-glossus
Facial artery
Lingual artery
Superior thyroid artery
Common carotid artery

BRANCHES OF THE ASCENDING PHARYNGEAL ARTERY

The ascending pharyngeal artery gives off the following **branches**:—(1) Prevertebral; (2) pharyngeal; (3) palatine; (4) tympanic; (5) meningeal.

(1) The **prevertebral** are distributed to the recti muscles, the fascia in front of

the vertebral column, and to the sympathetic nerve and lymphatic glands. These branches anastomose with branches of the ascending cervical. (2) The **pharyngeal** supply the superior and middle constrictor muscles and the mucous membrane lining them. These vessels anastomose with branches of the superior thyroid. (3) The **palatine** passes over the upper edge of the superior constrictor to the soft palate and its muscles. This branch follows a course similar to that taken by the ascending palatine artery, and when the latter is small may take its place. It generally gives off small twigs to the Eustachian tube and tonsil. (4) The **tympanic** accompanies the tympanic branch of the glosso-pharyngeal nerve through the tympanic canaliculus into the tympanum, and anastomoses with the other tympanic arteries. (5) The **meningeal** are distributed to the membranes of the brain. Some of these pass with the jugular vein through the jugular foramen into the cranium, and supply the dura mater in the posterior fossa of the skull. Others occasionally reach the same fossa through the anterior condyloid foramen in company with the hypoglossal nerve; while others pass through the cartilage of the middle lacerated foramen and supply the middle fossa of the skull.

2. THE SUPERIOR THYROID ARTERY

The **superior thyroid artery** arises from the front of the external carotid a little above the origin of that vessel, and, coursing forwards, inwards, and then downwards, in a tortuous manner, supplies the depressor muscles of the hyoid bone, the larynx, the thyroid body, and the lower part of the pharynx. The artery at first runs forwards and a little upwards, just beneath the greater cornu of the hyoid bone. In this part of its course it lies in the superior carotid triangle, and is quite superficial, being covered only with the integument, fascia, and platysma. It next turns downwards, and passes beneath the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles, and ends at the upper part of the thyroid body by breaking up into branches, some of which pass downwards in front, and others behind the lateral lobe of that structure to anastomose with ascending branches from the inferior thyroid; whilst others, again, but much smaller in size, pass in the substance of the isthmus across the front of the trachea to anastomose with the superior thyroid artery of the opposite side. These vessels, however, are so small, that if the isthmus is divided accurately in the middle line, there is practically no arterial hæmorrhage. From the branch to the thyroid body twigs are given off to the inferior constrictor and the upper part of the œsophagus. These anastomose with branches from the inferior thyroid. The superior thyroid vein passes beneath the artery on its way to the internal jugular vein. The superior thyroid is the artery most commonly divided in cases of suicidal wounds of the throat.

Branches of the Superior Thyroid Artery

The named **branches of the superior thyroid artery** are:—(1) The hyoid; (2) the sterno-mastoid; (3) the superior laryngeal; and (4) the crico-thyroid.

(1) The **hyoid**—or **infra-hyoid branch** as it is sometimes called, usually a small twig—passes along the lower border of the hyoid bone, lying on the thyro-hyoid membrane under cover of the thyro-hyoid and sterno-hyoid muscles. It supplies the infra-hyoid bursa, and the thyro-hyoid muscle, and anastomoses with its fellow of the opposite side, and with the supra-hyoid branch of the lingual. When the latter artery is small, the infra-hyoid is usually comparatively large, and *vice versa.*

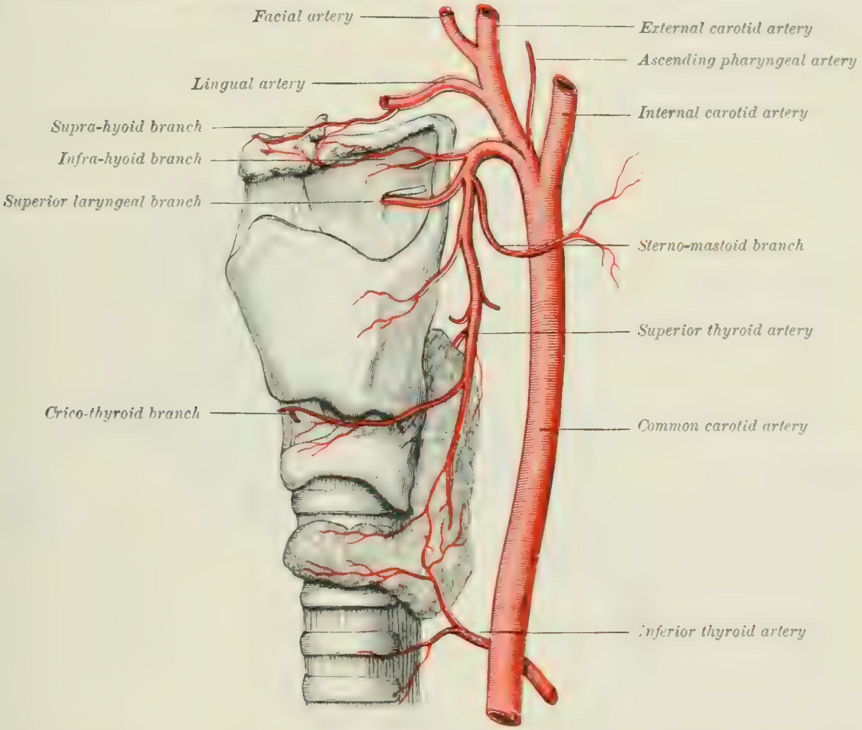
(2) The **sterno-mastoid** (fig. 332)—or **middle mastoid artery** as it is occasionally called—courses downwards and backwards across the carotid sheath, and entering the sterno-mastoid supplies the middle portion of that muscle. It gives off slender twigs to the thyro-hyoid, sterno-hyoid, and omo-hyoid muscles, and the platysma and integuments covering it. At times the vessel arises directly from the external carotid. It lies usually somewhere in the upper part of the incision for tying the common carotid above the omo-hyoid muscle.

(3) The **superior laryngeal** (fig. 329) passes inwards and forwards beneath

the thyro-hyoid muscle, and, perforating the thyro-hyoid membrane along with the superior laryngeal nerve, supplies the intrinsic muscles and mucous lining of the larynx. Its further distribution within the larynx is given with the description of that organ. This branch sometimes arises from the external carotid direct. It may enter the larynx by passing through a foramen in the thyroid cartilage.

(4) The **crico-thyroid**—or **inferior laryngeal branch** as it is sometimes called, usually insignificant in size—passes across the crico-thyroid membrane immediately beneath the lower border of the thyroid cartilage. It anastomoses with its fellow of the opposite side, and usually sends a small branch through the membrane into the interior of the larynx. Occasionally a considerable twig descends over the cricoid cartilage to enter the isthmus of the thyroid gland. The crico-thyroid has, however, frequently been seen of comparatively large size—once as large as the radial, and crossing the membrane obliquely. In order to avoid injuring the crico-thyroid artery in the operation of laryngotomy, it is usual, if the operation has to be done in a hurry, to make the incision through the crico-thyroid membrane in a transverse direction, and as near to the cricoid cartilage as possible.

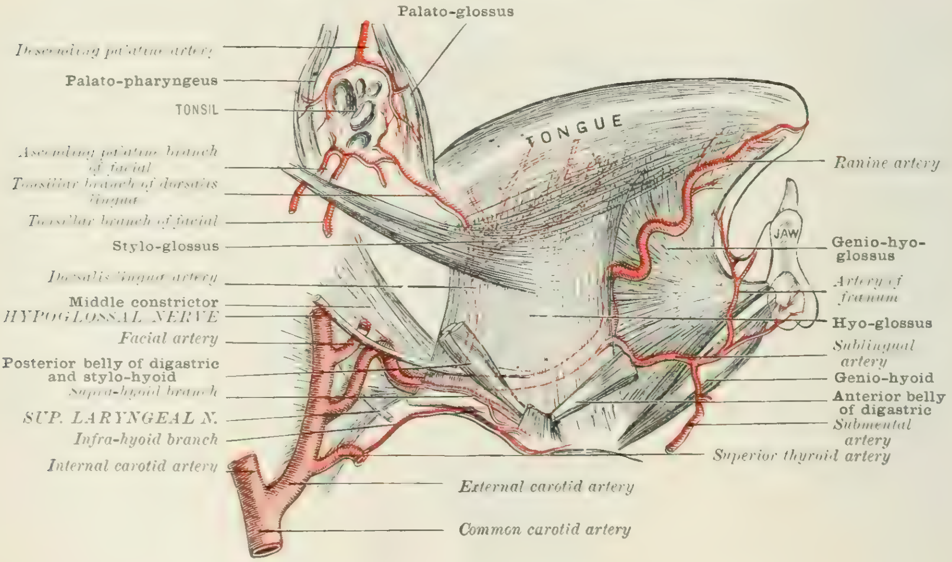
FIG. 332.—SCHEME OF LEFT SUPERIOR THYROID ARTERY. (Walsham.)


Facial artery
External carotid artery
Ascending pharyngeal artery
Lingual artery
Internal carotid artery
Supra-hyoid branch
Infra-hyoid branch
Superior laryngeal branch
Sterno-mastoid branch
Superior thyroid artery
Crico-thyroid branch
Common carotid artery
Inferior thyroid artery

3. THE LINGUAL ARTERY

The **lingual artery** (fig. 333) arises from the front of the external carotid, between the superior thyroid and facial arteries, often, as a common trunk with the latter vessel, and nearly opposite or a little below the greater cornu of the hyoid bone. It may, for purposes of description, be divided into three portions: the **first**, or **oblique**, extends from its origin to the outer edge of the hyo-glossus muscle; the **second**, or **horizontal**, lies beneath the hyo-glossus; the **third**, or **ascending**, beneath the tongue. The **first** or **oblique portion** is situated in the superior carotid triangle, and is superficial, being covered merely by the integuments, platysma, and deep fascia. Here it lies on the middle constrictor muscle and superior laryngeal nerve. After ascending a short distance, it curves downwards and forwards beneath the hypoglossal nerve, and, in the **second part of its course,** runs horizontally along the upper border of the hyoid bone, beneath the hyo-glossus, by which it is separated from the hypoglossal nerve, the posterior belly of the digastricus and the stylo-hyoid muscles, and the lingual vein. In this part of its course it lies successively on the middle constrictor of the pharynx and the genio-hyo-glossus muscle, and crosses a small triangular space known as 'Lesser's triangle,' the sides of which are formed by the tendons of the digastric, the base by the hypoglossal nerve, and the floor by the hyo-glossus muscle, in which situation it is usually tied. In the **third part of its course** it ascends tortuously, usually beneath the anterior margin of the hyo-glossus, to the under surface of the tongue, and is thence continued to the tip of that structure lying between the lingualis and the genio-hyo-glossus muscles. From the anterior edge of the hyo-glossus to its termination, it is only covered by the mucous membrane of the under surface of the tongue. This part of the vessel is sometimes called the ranine artery.

FIG. 333.—SCHEME OF THE RIGHT LINGUAL ARTERY. (Walsham.)


Palato-glossus
Descending palatine artery
Palato-pharyngeus
TONSIL
TONGUE
Ascending palatine branch of facial
Tonsillar branch of dorsalis linguæ
Tonsillar branch of facial
Stylo-glossus
Dorsalis linguæ artery
Middle constrictor
HYPOGLOSSAL NERVE
Facial artery
Posterior belly of digastric and stylo-hyoid
Supra-hyoid branch
SUP. LARYNGEAL N.
Infra-hyoid branch
Internal carotid artery
External carotid artery
Common carotid artery
Ranine artery
JAW
Genio-hyo-glossus
Artery of frænum
Hyo-glossus
Sublingual artery
Genio-hyoid
Anterior belly of digastric
Submental artery
Superior thyroid artery

BRANCHES OF THE LINGUAL ARTERY

The named **branches of the lingual artery** are:—(1) The hyoid; (2) the dorsalis linguæ; (3) the sublingual; and (4) the ranine.

(1) The **hyoid,** or **supra-hyoid** (fig. 333), is a small vessel which arises from the first part of the lingual, and courses along the upper border of the hyoid bone, superficial to the hyo-glossus, but beneath the insertion of the posterior belly of the digastricus and stylo-hyoid. It anastomoses with its fellow of the opposite side, and with the infra-hyoid, a branch of the superior thyroid artery, and supplies the contiguous muscles.

(2) The **dorsalis linguæ** (fig. 333) arises from the second portion of the lingual artery, usually under cover of the posterior edge of the hyo-glossus muscle. It ascends to the back of the dorsum of the tongue, and, dividing into branches, supplies the mucous membrane on each side of the V formed by the circumvallate papillæ. It also supplies the pillars of the fauces and the tonsil, where it anastomoses with the other faucial and tonsillar arteries. Instead of a single artery, as above described, there may be several small vessels running directly to the parts mentioned. The artery anastomoses in the mucous membrane by very small

branches with the vessel of the opposite side; but the anastomosis is so minute that when one lingual artery is injected, the injection merely passes across to the opposite side at the tip of the tongue; and when the tongue is divided accurately in the middle line, as in the removal of one-half of that organ, practically no haemorrhage occurs.

(3) The **sublingual artery** (fig. 333) usually comes off from the lingual at the anterior margin of the hyo-glossus. It passes beneath the mylo-hyoid to the sublingual gland, which it supplies, and, perforating the muscle, anastomoses with the submental artery, a branch of the facial. It also supplies branches to the side of the tongue, and gives off a terminal twig, which anastomoses beneath the mucous membrane of the floor of the mouth (to which it also gives twigs) with the artery of the opposite side. The **artery of the frænum** is usually derived from this vessel (fig. 333).

(4) The **ranine artery,** the termination of the lingual, courses forwards beneath the mucous membrane, on the under surface of the tongue, to the tip. It lies external to the genio-hyo-glossus, between that muscle and the inferior lingualis, and is accompanied by the ranine vein and terminal branch of the gustatory nerve. It follows a very tortuous course, so that it is not stretched when the tongue is protruded. Branches are given off from it to the contiguous muscles and mucous membrane. Near the tip of the tongue it communicates with its fellow of the opposite side, as shown by the fact that when the lingual artery of one side is injected the injection fluid passes into the branches of the artery of the other side.

4. THE FACIAL ARTERY

The **facial artery** (fig. 334)—also called the **external maxillary**—arises immediately above the lingual from the fore part of the external carotid, at times as a common trunk with the lingual. It courses forwards and upwards in a tortuous manner to the lower jaw, and, passing over the body of this bone at the anterior edge of the masseter muscle, winds obliquely upwards and forwards over the face to the inner canthus of the eye, where it inosculates, under the name of the **angular artery,** with the nasal branch of the ophthalmic. It is usually divided into two portions—the cervical and the facial.

The **cervical portion** (fig. 334) ascends tortuously from its origin from the external carotid upwards and forwards beneath the posterior belly of the digastric and stylo-hyoid muscles, and usually also beneath the hypoglossal nerve, and then making a turn runs horizontally forwards for a short way beneath the jaw, either imbedded in or lying under the submaxillary gland. It has here the mylo-hyoid and stylo-glossus beneath it. On leaving the cover of the gland it forms a loop passing first downwards and then upwards over the lower border of the jaw immediately in front of the masseter muscle, where it is superficial, being merely covered by the integument and platysma. Here it can be felt beating, and can be readily compressed. In the above course it lies in the posterior part of the submaxillary triangle, and, in addition to the structures already mentioned as crossing it, is covered by the skin, superficial fascia, and platysma, and by one or two submaxillary lymphatic glands. The vein is separated from the artery by the submaxillary gland, the posterior belly of the digastric muscle, the stylo-hyoid muscle, and the hypoglossal nerve.

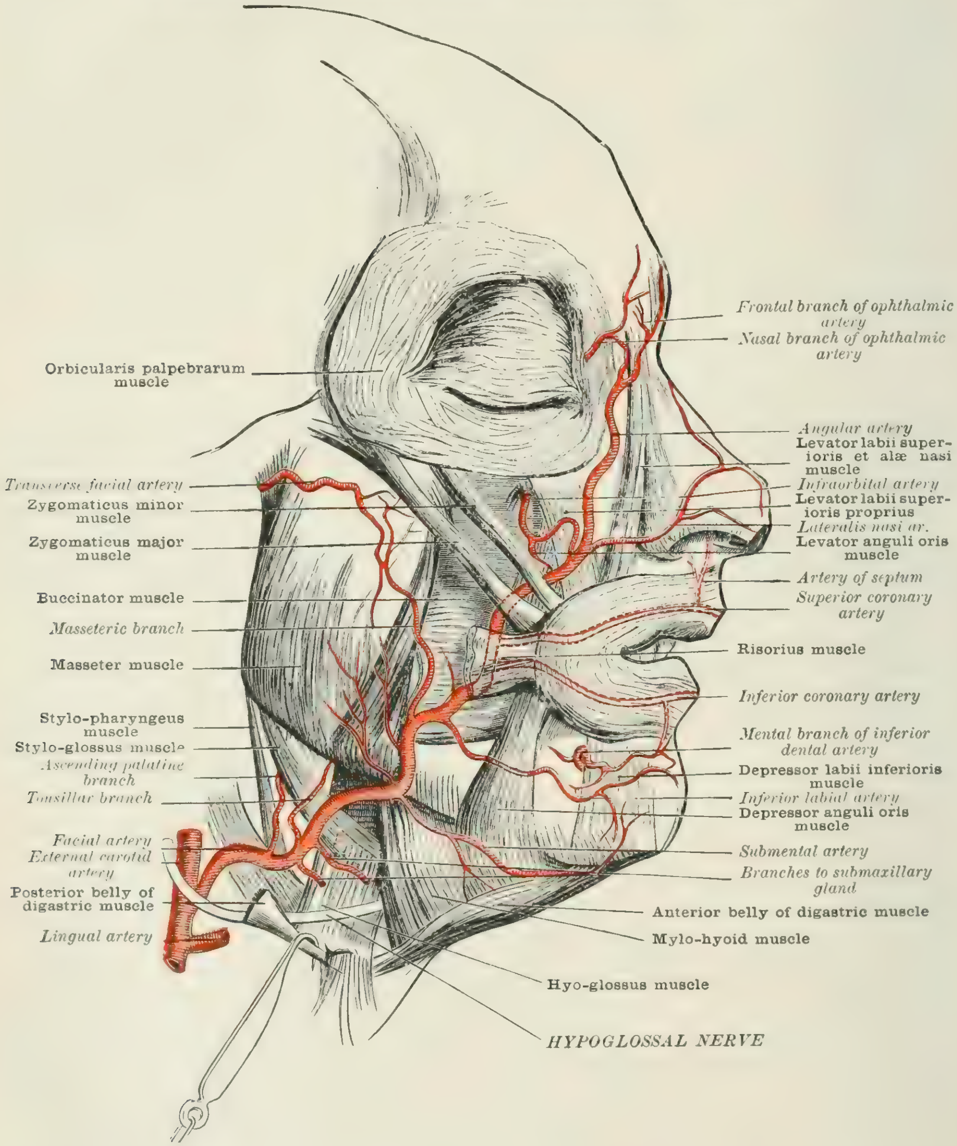
The **facial portion** (fig. 334) of the facial artery ascends tortuously forwards towards the angle of the mouth, passing under the platysma (risorius) and zygomatic muscles and the supramaxillary and buccal branches of the facial nerve. It here lies upon the jaw and the buccinator muscle. Thence it courses upwards by the side of the nose towards the inner canthus of the eye, being covered by the levator labii superioris, levator labii superioris alæque nasi, and infraorbital branches of the facial nerve, and lying on the levator anguli oris (sometimes on the levator labii superioris, instead of below it) and the infraorbital branches of the fifth nerve. The facial vein takes a much straighter course than the artery, is separated from it by the zygomatic muscles, and lies to its outer side.

BRANCHES OF THE FACIAL ARTERY IN THE NECK

The **branches of the facial artery in the neck** are:—(1) The ascending, or inferior palatine; (2) the tonsillar; (3) the glandular; (4) the muscular; (5) the submental.

(1) The **ascending,** or **inferior palatine** (figs. 333, 334)—the first branch of the facial, but often a distinct branch of the external carotid—ascends between the internal and external carotids, and then between the stylo-glossus and stylo-pharyngeus muscles, and on reaching the wall of the pharynx is continued upwards between the superior constrictor and internal pterygoid muscles towards the base of the skull as high as the levator palati, where it divides into two branches, a palatine and a tonsillar. One of these branches, the **palatine,** passes with the levator palati

FIG. 334.—SCHEME OF THE RIGHT FACIAL ARTERY. (Walsham.)


Frontal branch of ophthalmic artery
Nasal branch of ophthalmic artery
Orbicularis palpebrarum muscle
Angular artery
Levator labii superioris et alæ nasi muscle
Transverse facial artery
Infraorbital artery
Zygomaticus minor muscle
Levator labii superioris proprius
Lateralis nasi ar.
Zygomaticus major muscle
Levator anguli oris muscle
Artery of septum
Buccinator muscle
Superior coronary artery
Masseteric branch
Risorius muscle
Masseter muscle
Inferior coronary artery
Stylo-pharyngeus muscle
Mental branch of inferior dental artery
Stylo-glossus muscle
Ascending palatine branch
Depressor labii inferioris muscle
Tonsillar branch
Inferior labial artery
Depressor anguli oris muscle
Facial artery
Submental artery
External carotid artery
Branches to submaxillary gland
Posterior belly of digastric muscle
Anterior belly of digastric muscle
Lingual artery
Mylo-hyoid muscle
Hyo-glossus muscle
HYPOGLOSSAL NERVE

over the curved upper margin of the superior constrictor to the soft palate, where it is distributed to the tissues constituting that structure, and anastomoses with its fellow of the opposite side and with the descending palatine branch of the internal maxillary, and the ascending pharyngeal, which vessel often to a great extent supplies the place of this artery. The other branch, the **tonsillar**, supplies the tonsil and the Eustachian tube, anastomosing with the tonsillar branch of the facial and ascending pharyngeal arteries. The ascending palatine artery supplies the muscles between which it runs on its way to the palate.

(2) The **tonsillar branch** (fig. 334) ascends between the stylo-glossus and internal pterygoid muscles to the level of the tonsil, where it perforates the superior constrictor muscle of the pharynx, and ends in the tonsil, anastomosing with the tonsillar branch of the ascending palatine and with the other tonsillar arteries (fig. 333). It gives branches also to the root of the tongue.

(3) The **glandular** or **submaxillary branches** are distributed to the submaxillary gland as the artery is passing through or beneath that structure. A small twig from one of these branches usually supplies Wharton's duct.

(4) The **muscular branches** are small twigs given off irregularly to the contiguous muscles, viz. the posterior belly of the digastric, the stylo-hyoid, the stylo-glossus, and the mylo-hyoid muscles.

(5) The **submental branch** (fig. 334) comes off from the facial as the latter vessel lies under cover of the submaxillary gland, and, passing forwards on the mylo-hyoid muscle between the base of the jaw and the anterior belly of the digastricus, supplies these structures and the overlying platysma and integuments. It gives off the following small branches:—(*a*) **muscular,** to the muscles between which it runs; (*b*) **perforating,** which passes through the mylo-hyoid to anastomose with the sublingual; (*c*) **cutaneous,** to the integuments covering it; (*d*) **mental,** which turns over the border of the lower jaw near the symphysis, and, after supplying a branch to the depressor labii inferioris, the levator menti, and the other adjacent soft tissues forming the chin and lip, anastomoses with the mental branch of the inferior dental, the inferior labial, and the artery of the opposite side.

Branches of the Facial Artery on the Face

From the **outer** or **concave** side of the artery are given off:—(1) **masseteric branches** which ascend over the masseter to anastomose with the masseteric branch of the internal maxillary artery and the transverse facial artery; and (2) **buccal,** which pass upwards over the buccinator and anastomose with the buccal branch of the internal maxillary, the transverse facial, and the infraorbital arteries.

From the **inner** or **convex** side the following larger and named vessels are given off:—(1) The inferior labial; (2) the inferior coronary; (3) the superior coronary; (4) the lateralis nasi; and (5) the angular.

(1) The **inferior labial artery** arises either separately from the facial artery, or in common with the next branch—the inferior coronary. It courses forwards beneath the depressor anguli oris, and over the depressor labii inferioris, and, after supplying the contiguous muscles and integuments, anastomoses below with the submental, above with the inferior coronary, and between the two with the mental branch of the inferior dental which escapes from the mental foramen.

(2) The **inferior coronary artery** arising from the facial a little above the inferior labial, or in common with it, passes forwards beneath the depressor anguli oris towards the angle of the mouth, thence skirts along the lower lip, between the mucous membrane and orbicularis oris, about a quarter to half an inch from the junction of the skin and mucous membrane, and anastomoses with its fellow of the opposite side. It can readily be felt beating during life by pressing the lip between finger and thumb. It gives off descending branches which anastomose with the inferior labial and the mental branch of the inferior dental (or mandibular) artery.

(3) The **superior coronary artery,** arising from the facial a little higher than the inferior coronary, passes forwards beneath the zygomaticus major, and then, like the inferior coronary, courses tortuously along the lower margin of the upper lip between the orbicularis oris and the mucous membrane about half an inch

from the junction of the mucous membrane and the skin. It is usually larger than the inferior coronary. The superior coronary anastomoses with its fellow of the opposite side, and gives off a small artery to the septum—**arteria septi nasi.** Compression of this vessel will sometimes control hæmorrhage from the nose.

In the operation for hare lip, the pin or suture should be passed sufficiently deep to transfix the divided coronary artery, or hæmorrhage may continue into the mouth. Bleeding from either coronary vessel can be readily controlled by the thumb and forefinger grasping the lip.

(4) The **lateral nasal artery** (fig. 334) is a small twig or twigs given off from the facial opposite the ala of the nose. It passes forwards over the ala and lower part of the nose, supplying the integuments, muscles, and cartilages, and anastomoses with the artery of the septum, the vessel of the opposite side, and the nasal branches of the ophthalmic.

(5) The **angular artery** (fig. 334) is the name given to the termination of the facial artery. It anastomoses at the inner canthus of the eye with the nasal branch of the ophthalmic. It is accompanied by the anterior descending vein from the scalp. It lies to the inner side of the lachrymal sac, and supplies that structure and the lower part of the orbicularis oculi, beneath which a branch anastomoses with the infraorbital artery. The situation of the artery to the inner side of the lachrymal sac should be borne in mind in opening a lachrymal abscess.

5. THE OCCIPITAL ARTERY

The **occipital artery** (fig. 335) is usually a vessel of considerable size. It comes off from the posterior part of the external carotid opposite the facial, or else a little higher than that vessel. It then winds upwards and backwards to the interval between the mastoid process of the temporal bone and transverse process of the atlas, and, after running horizontally backwards in the occipital groove on the mastoid portion of the temporal bone, again turns upwards, and ends by ramifying in the scalp over the back of the skull, extending as far forwards as the vertex.

The vessel may be divided into three parts—viz. that internal to the sterno-mastoid muscle; that beneath the sterno-mastoid; and that external to the sterno-mastoid.

In the **first part of its course** the occipital artery is covered by the integuments and fascia, and is more or less overlapped by the posterior belly of the digastric muscle, the parotid gland, and temporo-maxillary vein. It is crossed by the hypo-glossal nerve as the latter winds forwards over the carotid vessels to reach the tongue. It successively crosses in front of the internal carotid artery, the hypoglossal nerve, the pneumogastric nerve, the internal jugular vein, and the spinal accessory nerve.

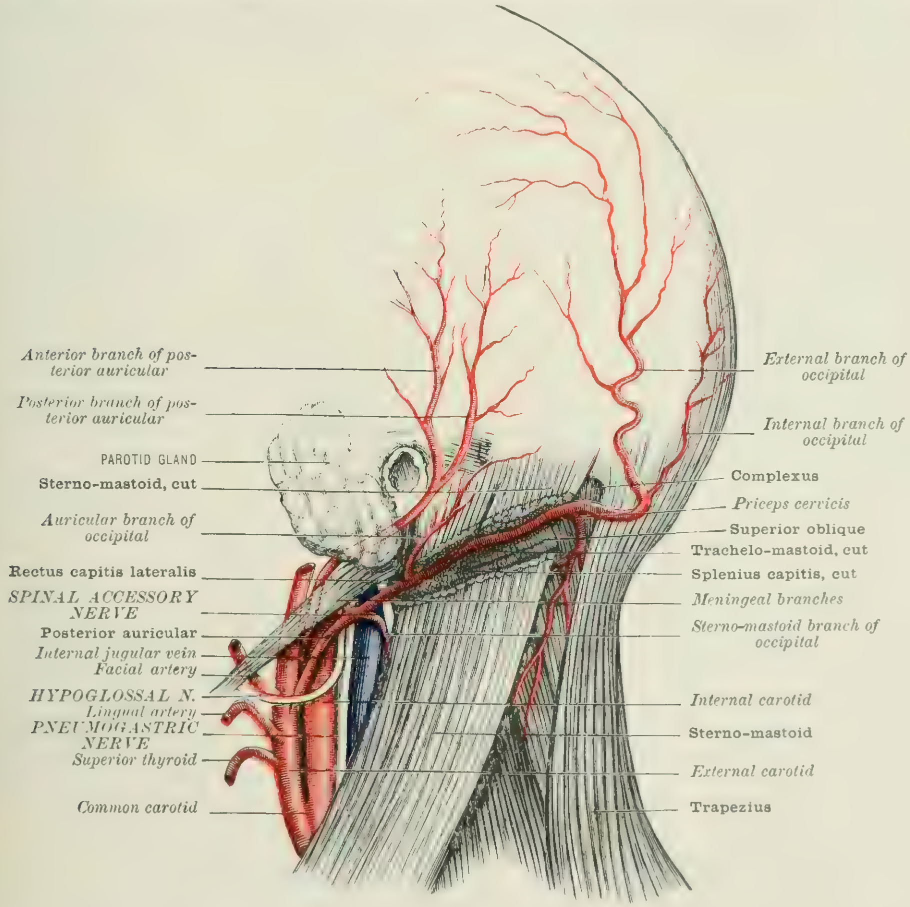
In the **second part of its course** it sinks deeply beneath the digastric muscle into the interval between the mastoid process of the temporal bone and the transverse process of the atlas. It is here covered by the sterno-mastoid, splenius capitis, and trachelo-mastoid muscles and by the origin of the digastricus; and lies, first on the rectus capitis lateralis, which separates it from the vertebral artery, then in the occipital groove on the mastoid portion of the temporal bone, and then on the insertion of the superior oblique muscle.

In the **third part of its course** it enters the triangular interval formed by the diverging borders of the splenii capitis and the superior curved line of the occipital bone. Here it lies beneath the integuments and the aponeurosis uniting the occipital attachments of the sterno-mastoid and trapezius, and rests upon the complexus just before the insertion of that muscle into the occipital bone. In company with the great occipital nerve, it perforates either this aponeurosis, or less often the posterior belly of the occipito-frontalis, and follows roughly, but in a tortuous course, the line of the lambdoid suture lying between the integument and the cranial aponeurosis. In the scalp it divides into several large branches, which ramify over the back of the skull and reach as far forwards as the vertex. They anastomose with the corresponding branches of the opposite side, and with the posterior auricular, and the superficial temporal arteries.

BRANCHES OF THE OCCIPITAL ARTERY

The **branches of the occipital artery** are:—(1) The sterno-mastoid; (2) the posterior meningeal; (3) the auricular; (4) the mastoid; (5) the princeps cervicis; (6) the communicating; (7) the muscular; and (8) the terminal. The sterno-mastoid, posterior meningeal, auricular, and princeps cervicis are the four vessels usually named amongst the above branches.

FIG. 335.—SCHEME OF RIGHT OCCIPITAL AND POSTERIOR AURICULAR ARTERIES. (Walsham.)


Anterior branch of posterior auricular
Posterior branch of posterior auricular
PAROTID GLAND
Sterno-mastoid, cut
Auricular branch of occipital
Rectus capitis lateralis
SPINAL ACCESSORY NERVE
Posterior auricular
Internal jugular vein
Facial artery
HYPOGLOSSAL N.
Lingual artery
PNEUMOGASTRIC NERVE
Superior thyroid
Common carotid
External branch of occipital
Internal branch of occipital
Complexus
Priceps cervicis
Superior oblique
Trachelo-mastoid, cut
Splenius capitis, cut
Meningeal branches
Sterno-mastoid branch of occipital
Internal carotid
Sterno-mastoid
External carotid
Trapezius

(1) The **sterno-mastoid branch** (fig. 335) usually comes off from the occipital just after its origin from the carotid, and, passing downwards and backwards over the loop of the hypoglossal nerve, enters the sterno-mastoid muscle in company with the spinal accessory nerve. At times this artery is a distinct branch of the external carotid. The hypoglossal nerve then as a rule loops round it instead of round the occipital.

(2) The **posterior meningeal branches** (fig. 335), one or more in number, are long slender vessels which leave the occipital artery as it crosses the internal jugular vein, and, ascending along that vessel, pass with it through the jugular foramen, and are distributed to the dura mater lining the posterior fossa of the skull.

(3) The **auricular branch** ascends over the mastoid process to the back of the ear, and supplies the pinna and concha. It sometimes takes the place of the posterior auricular artery (fig. 335).

(4) The **mastoid branch** is a small twig that passes into the skull through the mastoid foramen, supplying the dura mater, the diploë, the walls of the lateral sinus and the mastoid cells.

(5) The **princeps cervicis** (fig. 335), the largest of the branches of the occipital, arises from that artery just before it emerges from beneath the splenius, and, descending for a short distance between the splenius and complexus, divides into a superficial and a deep branch. The **superficial branch** perforates the splenius, supplies branches to the trapezius, and anastomoses with the superficial cervical, a branch of the transverse cervical artery. The **deep branch** passes downwards between the complexus and semispinalis colli, and anastomoses with the deep cervical branch of the superior intercostal and with branches of the vertebral (fig. 338). The anastomoses between the above-mentioned arteries form important collateral channels after ligature of the common carotid and subclavian arteries (fig. 330).

(6) The **communicating branches** run deeply into the triangle formed by the superior oblique, inferior oblique, and rectus capitis posticus major muscles, and there anastomose with branches of the vertebral.

(7) **Muscular branches** throughout the course of the occipital artery are distributed to the contiguous muscles—viz. in addition to the sterno-mastoid which receives a named branch, to the digastricus, stylo-hyoid, splenius, trachelo-mastoid, trapezius, the small muscles forming the suboccipital triangle, and the posterior belly of the occipito-frontalis.

(8) The **terminal** or **superficial branches** (fig. 335), usually two in number, named from their position internal and external, ramify over the scalp, and have already been described. The internal branch generally gives off a twig which enters the parietal foramen (parietal artery) and is distributed to the dura mater. The occipital artery may also give off the stylo-mastoid, the posterior auricular, or the ascending pharyngeal arteries.

6. THE POSTERIOR AURICULAR ARTERY

The **posterior auricular artery** (fig. 335) arises from the posterior part of the external carotid artery, usually immediately above the posterior belly of the digastric, about the level of the tip of the styloid process. Occasionally it arises under cover of the digastric, quite close to, or as a common trunk with, or as a branch of, the occipital. It courses upwards and backwards in the parotid gland to the notch between the margin of the external auditory meatus and the mastoid process, where it divides into two branches, an anterior or auricular, and a posterior or mastoid. In this course it rests on the styloid process, crosses the spinal accessory nerve, and is crossed itself by the facial nerve.

Branches of the Posterior Auricular Artery

The **branches of the posterior auricular artery** are:—(1) The parotid; (2) the muscular; (3) the stylo-mastoid; (4) the anterior terminal, or auricular; (5) the posterior terminal, or mastoid (fig. 335).

(1) The **parotid branches** are distributed to the lower portion of the parotid gland, and anastomose with the other parotid arteries.

(2) The **muscular branches** supply the posterior belly of the digastricus, the stylo-hyoid, and retrahens aurem muscles.

(3) The **stylo-mastoid branch** comes off from the posterior auricular artery just before it reaches the notch between the margin of the external auditory meatus and the mastoid process, and, following the facial nerve upwards, enters the stylo-mastoid foramen in the temporal bone. In the aqueduct of Fallopius it gives off the following named twigs:—(*a*) **meatal**, to the external auditory meatus; (*b*) **mastoid**, to the mastoid cells and mastoid antrum; (*c*) **stapedic**, which runs for-

wards to the stapedius muscle; (*d*) **tympanic,** which anastomoses with the tympanic branch of the internal maxillary, forming with it in the fœtus a vascular circle around the membrana tympani; (*e*) **vestibular,** to the vestibule and semicircular canals; and (*f*) **terminal,** a small twig which enters the hiatus Fallopii with the great superficial petrosal nerve, and anastomoses with the petrosal branch of the large middle meningeal artery.

(4) The **anterior terminal** or **auricular branch** passes upwards behind the ear and beneath the retrahens aurem, supplying the back of the pinna and neighbouring integuments. It anastomoses with the posterior branch of the superficial temporal artery. The branches to the pinna not only supply the back of that structure, but some perforate the cartilage, and others turn over its free margin to supply the front surface; there they anastomose with the anterior auricular branches from the temporal.

(5) The **posterior terminal,** or **mastoid** or **occipital branch,** passes upwards and backwards, crossing the aponeurotic insertion of the sterno-mastoid muscle. It gives a branch to the posterior belly of the occipito-frontalis, and anastomoses with the occipital artery.

7. THE TEMPORAL ARTERY

The **temporal artery,** or **superficial temporal artery**—the smaller of the two terminal divisions of the external carotid, though apparently the direct continuation of that vessel—arises opposite the neck of the lower jaw and, under cover of the parotid gland, passes upwards in the interval between the condyle and the external auditory meatus to the zygoma, lying on the capsule of the joint. Thence it ascends over the posterior root of that process and the temporal aponeurosis for about an inch and a half to two inches (4 cm.), and there divides into an anterior and a posterior branch. It is surrounded by a dense plexus of sympathetic nerves, and is accompanied by the auriculo-temporal nerve, which lies beneath and generally a little behind it. It is crossed by the temporo-facial division of the facial nerve, and by the attrahens aurem muscle. As it crosses the zygoma it can be readily felt pulsating immediately in front of the ear, and in this situation can be compressed against the bone. It is here quite superficial, being merely covered by the integuments and a delicate prolongation from the cervical fascia.

Branches of the Temporal Artery

The **branches of the temporal artery** are:—(1) The parotid; (2) the articular; (3) the masseteric; (4) the auricular, or anterior auricular; (5) the transverse facial; (6) the middle temporal; (7) the orbital; (8) the anterior terminal; (9) the posterior terminal.

(1) The **parotid branches** are small twigs given off in the substance of the parotid gland to that structure.

(2) The **articular branches** supply the temporo-maxillary joint.

(3) The **masseteric** are one or two small branches to the masseter muscle.

(4) The **auricular** or **anterior auricular branches** supply the tragus, the pinna, and the lobule of the ear, and to some extent the external auditory meatus.

(5) The **transverse facial** is the largest branch of the temporal. It sometimes arises from the external carotid as a common trunk with the temporal. It is at first deeply seated in the substance of the parotid gland, but, soon emerging from under that part of the gland known as the socia parotidis, courses transversely across the masseter muscle about a finger's breadth below the zygoma. Steno's duct runs below it, and the infraorbital branches of the facial nerve above it. It supplies the parotid gland, the masseter muscle, and the skin of the face, and anastomoses with the infraorbital, the buccal, and the facial arteries.

(6) The **middle temporal branch,** or **middle deep temporal artery** (fig. 336), arises just above the zygoma, and, perforating the temporal aponeurosis and temporal muscle, ascends on the squamous portion of the temporal bone, and anastomoses with the posterior deep temporal artery.

(7) The **orbital** or **zygomatico-orbital branch** (fig. 336), as it is sometimes

called—at times a branch of the deep temporal—passes forwards along the upper border of the zygoma in the fat between the superficial and deep layers of the temporal aponeurosis, and, after giving branches to the orbicularis oculi, sends one or more twigs into the orbit through the orbital foramina in the malar bone to anastomose with the lachrymal and palpebral branches of the ophthalmic.

(8) The **anterior terminal branch** ramifies tortuously in an upward and forward direction over the front part of the skull. It lies, first between the skin and temporal fascia, and then between the skin and occipito-frontalis aponeurosis. It supplies the anterior belly of the occipito-frontalis and the orbicularis oculi muscles, and anastomoses with the supraorbital, supratrochlear, and frontal branches of the ophthalmic, and with the corresponding artery of the opposite side. The **secondary branches** given off from this vessel to the scalp run from before backwards.

(9) The **posterior terminal branch** ramifies on the side of the head between the skin and temporal fascia. Its branches anastomose, in front with the anterior terminal branch; behind, with the posterior auricular and occipital arteries; and above, across the vertex of the skull, with the corresponding artery of the opposite side.

8. THE INTERNAL MAXILLARY ARTERY

The **internal maxillary artery** (fig. 336) is the larger of the two terminal divisions of the external carotid. It arises opposite the neck of the jaw in the substance of the parotid gland, and, passing first between the neck of the jaw and the spheno-mandibular ligament—the so-called internal lateral ligament of the lower jaw—and then between the external and internal pterygoid muscles, sinks deeply into the spheno-maxillary fossa, and there breaks up into its terminal branches. It is divided into three portions: a maxillary, a pterygoid, and a spheno-maxillary.

(1) In the **first part of its course** (the **maxillary portion**) the artery lies between the neck of the jaw and the spheno-mandibular ligament, taking a horizontal course forwards and inwards parallel to and a little below the auriculo-temporal nerve and the external pterygoid muscle. It is here embedded in the deep portion of the parotid gland, and usually crosses in front of the mandibular (inferior dental) nerve.

(2) In the **second part of its course** (the **pterygoid portion**) the artery lies either between the two pterygoid muscles and the ramus of the jaw, and then turns upwards over the outer surface of the external pterygoid, beneath the temporal muscle to gain the two heads of the external pterygoid, between which it sinks into the spheno-maxillary fossa; or it passes behind and internal to the external pterygoid, and is covered by that muscle till it reaches the interval between its two heads, where it then often forms a projecting loop as it turns into the spheno-maxillary fossa.

(3) In the **third part of its course** (the **spheno-maxillary portion**) the artery lies in the spheno-maxillary fossa beneath the maxillary division of the fifth nerve, and in close relationship with Meckel's ganglion, and there breaks up into its terminal branches.

Branches of the Internal Maxillary Artery

The **branches of the internal maxillary artery** are:—

(A) **From the first part**:—(1) The deep auricular; (2) the tympanic; (3) the large middle meningeal; (4) the mandibular (inferior dental); (5) the small middle meningeal (sometimes). All these vessels pass through bony or cartilaginous canals.

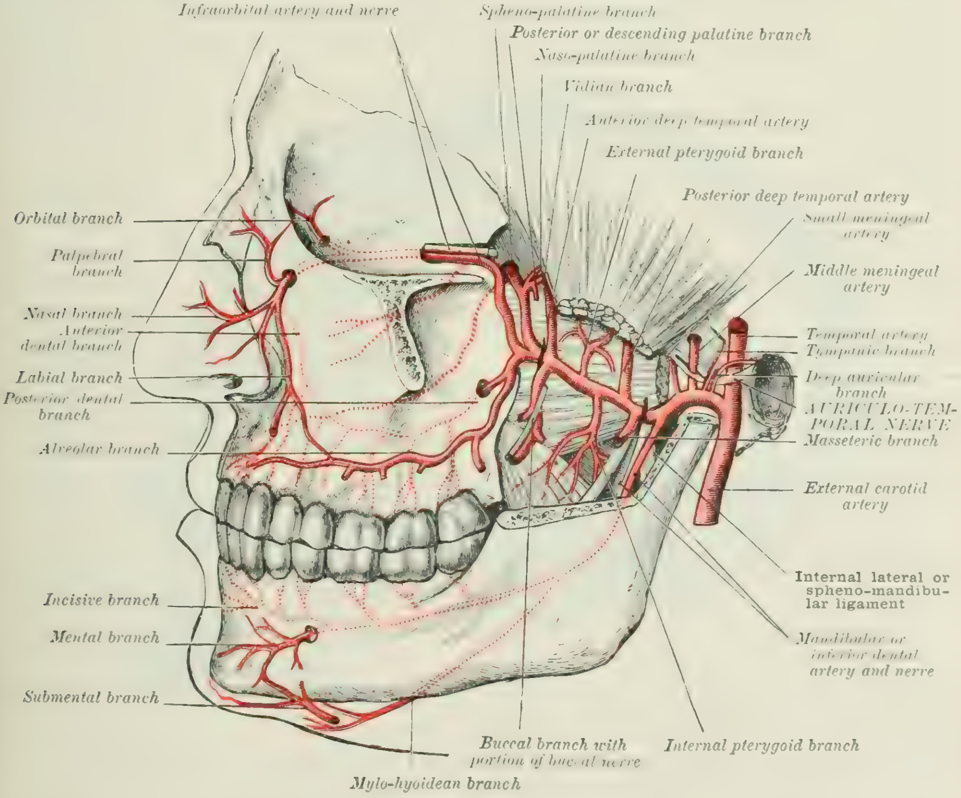
(B) **From the second part**:—(1) The masseteric; (2) the posterior deep temporal; (3) the internal pterygoid; (4) the external pterygoid; (5) the buccal; and (6) the anterior deep temporal. All these branches supply muscles.

(C) **From the third part**:—(1) The posterior dental, or alveolar; (2) the infra-orbital; (3) the posterior, or descending palatine; (4) the Vidian; (5) the pterygo-palatine; and (6) the naso- or spheno-palatine. All these branches pass through bony canals.

Branches of the First Part of the Internal Maxillary Artery.—(1) The **deep auricular** (fig. 336) passes upwards in the substance of the parotid gland behind the capsule of the temporo-maxillary joint, and, perforating the bony or cartilaginous wall of the external auditory meatus, supplies the skin of that passage and the membrana tympani. It at times gives a branch to the joint as it passes behind the temporo-maxillary capsule.

(2) The **tympanic branch,** or **Glaserian artery,** is a long slender vessel, which runs upwards behind the condyle of the jaw to the Glaserian fissure, through which it passes to the interior of the tympanum. Here it supplies the lining membrane of that cavity and the laxator tympani muscle, and anastomoses with the other tympanic arteries, forming with the tympanic branch of the stylo-mastoid artery a vascular circle around the membrana tympani. This circle is more distinct in the fœtus than in the adult.

FIG. 336.—SCHEME OF LEFT INTERNAL MAXILLARY ARTERY. (Walsham.)


Infraorbital artery and nerve
Spheno-palatine branch
Posterior or descending palatine branch
Naso-palatine branch
Vidian branch
Anterior deep temporal artery
External pterygoid branch
Posterior deep temporal artery
Small meningeal artery
Middle meningeal artery
Orbital branch
Palpebral branch
Nasal branch
Anterior dental branch
Labial branch
Posterior dental branch
Alveolar branch
Temporal artery
Tympanic branch
Deep auricular branch
AURICULO-TEMPORAL NERVE
Masseteric branch
External carotid artery
Internal lateral or spheno-mandibular ligament
Incisive branch
Mental branch
Mandibular or inferior dental artery and nerve
Submental branch
Buccal branch with portion of buccal nerve
Internal pterygoid branch
Mylo-hyoidean branch

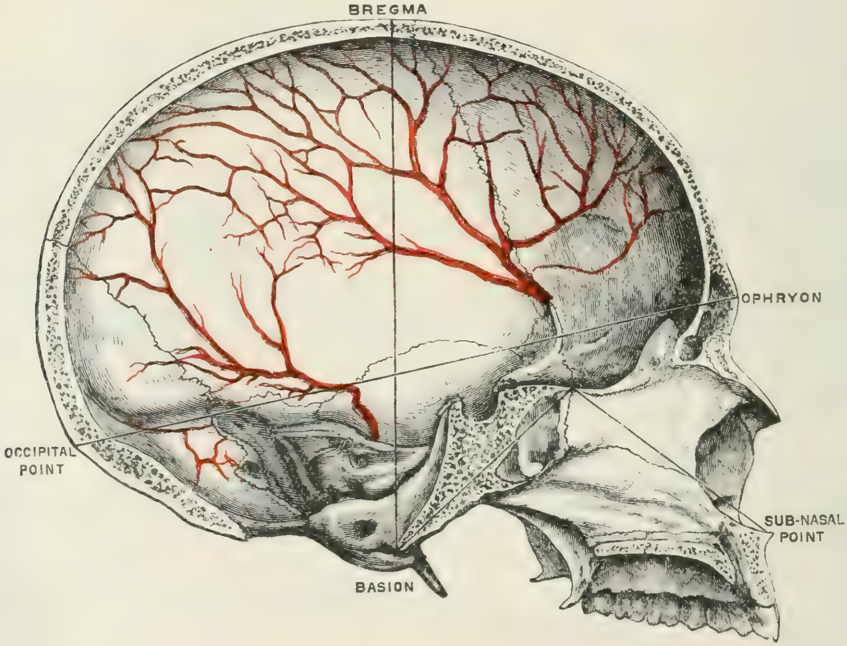
(3) The **large middle meningeal** is the largest branch of the internal maxillary artery. It comes off from that vessel as it lies between the spheno-mandibular ligament and the ramus of the jaw, and under cover of the external pterygoid passes directly upwards to the foramen spinosum, through which it enters the interior of the cranium. In this part of its course it is crossed by the chorda tympani nerve; and just before it enters the foramen is embraced by the two heads of origin of the auriculo-temporal nerve (fig. 336).

The trunk of the mandibular division of the fifth nerve, as the latter emerges through the foramen ovale, lies in front of the artery. As the artery passes upwards it is surrounded by filaments of the sympathetic nerve, and is accompanied by two veins which open into the internal maxillary vein. On entering the skull it ramifies between the bone and dura mater, supplying both structures. It at first ascends for a short distance in a groove on the greater wing of the sphenoid, and then divides into two branches, an anterior and a posterior.

The **anterior branch** passes upwards, in the groove on the greater wing of the sphenoid, on to the parietal bone at its anterior and inferior angle; at this spot the groove becomes deepened and often bridged over by a thin plate of bone, being converted for a quarter to half an inch or more into a distinct canal. The situation of the artery is here indicated on the exterior of the skull by a spot an inch and a half behind, and about an inch above, the external angular process of the orbit. The anterior branch is continued along the anterior border of the parietal bone nearly as far as the superior longitudinal sinus, and gives off in its course, but especially posteriorly, large branches which ramify in an upward and backward direction in grooves on the parietal bone (fig. 337).

The **posterior branch** passes backwards over the squamous portion of the temporal bone; and thence on to the parietal bone, behind the anterior branch. This branch and its collaterals extend upwards as far as the longitudinal sinus, and backwards as far as the lateral sinus.

FIG. 337.—THE MIDDLE MENINGEAL ARTERY WITHIN THE SKULL.



In addition to its terminal anterior, and terminal posterior branches, the middle meningeal gives off:—(*a*) **Gasserian branches** to the Gasserian ganglion and Meckel's space. (*b*) A **petrosal branch,** which enters the hiatus Fallopii in company with the large superficial petrosal nerve and anastomoses with the terminal branch of the stylo-mastoid artery. (*c*) A **tympanic branch,** which enters the canal for the tensor tympani, and supplies that muscle. (*d*) An **orbital** or **lachrymal branch,** which enters the orbit at the outermost part of the sphenoidal fissure, or sometimes through a minute foramen, just external to that fissure, and anastomoses with the lachrymal branch of the ophthalmic. (*e*) **Anastomotic** or **perforating branches** which pierce the greater wing of the sphenoid bone, and anastomose with the deep temporal arteries.

(4) The **mandibular (inferior dental) artery** (fig. 336), arising from the internal maxillary as it lies between the spheno-mandibular ligament and neck of the jaw, courses downwards to the mandibular foramen, which it enters in company

with, and a little behind and external to, the mandibular nerve. It then passes along the canal in the interior of the bone, giving off branches to the molar, bicuspid, and canine teeth. On reaching the mental foramen it divides into two branches, the incisive and the mental. The **incisive** continues its course in the bone, and supplies branches to the incisor teeth, and anastomoses with the artery of the opposite side. The **mental** passes through the mental foramen in company with the mental branch of the mandibular (inferior dental) nerve, and emerges on the chin under cover of the depressor labii inferioris. It anastomoses above with the inferior coronary, and below with the submental, and also with the inferior labial. Near its origin the artery gives off (*a*) a **lingual** or **gustatory branch,** which accompanies and supplies the lingual nerve, and ends in the mucous membrane of the mouth; and, just before it enters the dental foramen in the lower jaw, (*b*) a **mylo-hyoidean branch,** which accompanies the nerve of that name along the groove in the lower jaw, and, after supplying the mylo-hyoid muscle, anastomoses with the sublingual and submental arteries.

(5) The **small meningeal** arises either from the internal maxillary a little in front of the large middle meningeal, or as a branch of that vessel. It passes upwards along the course of the mandibular division of the fifth nerve, and, entering the skull through the foramen ovale, is distributed to the Gasserian ganglion, and to the walls of the cavernous sinus and the dura mater in the neighbourhood.

Branches of the Second Part of the Internal Maxillary Artery.—The branches of the second portion of the internal maxillary all supply muscles. They are:—(1) The masseteric; (2) the posterior deep temporal; (3) the internal pterygoid; (4) the external pterygoid; (5) the buccal; and (6) the anterior deep temporal.

(1) The **masseteric branch** comes off from the internal maxillary as the latter is passing from between the neck of the jaw and the spheno-mandibular ligament. It is directed outwards along with the masseteric nerve, and, passing through the sigmoid notch in the lower jaw, supplies the masseter muscle. Some filaments perforate the muscle and anastomose with the transverse facial and with the masseteric branches of the facial itself.

(2) The **posterior deep temporal** arises, as a rule, from the internal maxillary in common with the masseteric or a little beyond that branch. It passes upwards beneath the temporal muscle in a slight groove on the anterior margin of the squamous portion of the temporal bone, supplying the temporal muscle, the pericranium, and the external layer of the bone. It anastomoses with the anterior deep temporal and the other temporal arteries.

(3) The **internal pterygoid branches** are short trunks which pass into and supply the internal pterygoid muscle.

(4) The **external pterygoid branches** supply the external pterygoid muscle, and, like the internal pterygoid branches, are short trunks, and very irregular in their number, origin, and distribution.

(5) The **buccal branch** (fig. 336) courses forwards and downwards with the buccal nerve to the buccinator muscle, lying in close contact with the inner side and anterior margin of the tendon of the temporal muscle and coronoid process of the lower jaw. It supplies the buccinator muscle and mucous membrane of the mouth, and anastomoses with the facial, transverse facial, and infraorbital arteries.

(6) The **anterior deep temporal branch** ascends beneath the temporal muscle in a slight groove on the greater wing of the sphenoid bone. It supplies the muscle, pericranium, and subjacent bone, and gives off small branches which pass through minute foramina in the malar bone. Some of these last branches enter the orbit and anastomose with the lachrymal artery; others emerge on the face and anastomose with the transverse facial artery.

Branches of the Third Part of the Internal Maxillary Artery.—The branches of the third part of the internal maxillary artery, like those of the first part, all pass through bony canals. They are the following:—(1) The posterior dental, or alveolar; (2) the infraorbital; (3) the posterior, or descending palatine; (4) the Vidian; (5) the pterygo-palatine; and (6) the naso-palatine, or spheno-palatine.

(1) The **posterior dental** or **alveolar branch** arises from the internal maxillary as the latter is passing into the spheno-maxillary fossa, and descends in a tortuous manner in a groove on the back of the body of the maxilla. It gives off the fol-

lowing branches:—(*a*) **Antral,** which pass through small foramina into the antrum; (*b*) **dental,** which pass into bony canals to supply the molar and bicuspid teeth; (*c*) **alveolar,** or **gingival,** which supply the gums; and (*d*) **buccal,** which are distributed to the buccinator muscle.

(2) The **infraorbital branch** arises from the internal maxillary, generally as a common trunk with the posterior dental. It passes forwards and a little upwards through the spheno-maxillary fossa; then forwards in company with the maxillary division of the fifth nerve, first along the groove, and then through the canal in the orbital plate of the maxilla; and finally, emerging on the face at the infraorbital foramen, under cover of the levator labii superioris proprius, is distributed to the structures forming the upper lip, the lower eyelid, the lachrymal sac, and the side of the nose. It anastomoses with the superior coronary and angular branches of the facial, with the nasal and lachrymal branches of the ophthalmic, and with the transverse facial. It gives off the following small branches:—(*a*) **Orbital,** to the fat of the orbit and to the inferior rectus and inferior oblique muscles; (*b*) an **anterior dental branch,** which passes downwards through a groove in the anterior wall of the superior maxilla, together with the anterior dental branch of the infraorbital nerve, and supplies branches to the incisor and canine teeth and the mucous membrane of the antrum; and (*c*) **nasal branches,** which pass through the foramina in the nasal process of the superior maxilla (sutura notha).

(3) The **posterior** or **descending palatine branch** descends in the posterior palatine canal with the great or anterior palatine branch of Meckel's ganglion. On emerging on the palate at the posterior palatine foramen, it divides into the following branches:—(*a*) An **anterior branch,** which courses forwards in the muco-periosteum at the junction of the hard palate with the alveolar process as far as the anterior palatine foramen, where it anastomoses with the naso-palatine artery; and (*b*) **posterior branches,** which pass backwards and downwards into the soft palate, contributing to the supply of that structure, and anastomosing with the ascending palatine artery. After the operation for cleft palate, serious hæmorrhage occasionally occurs from the descending palatine artery. It may be stopped by compressing the artery by means of a plug inserted in the posterior palatine foramen. The foramen is situated a little behind, and internal to, the last molar tooth, and almost immediately in front of the hamular process.

(4) The **Vidian artery** is a long slender branch which passes backwards through the Vidian canal in company with the Vidian nerve into the cartilage of the middle lacerated foramen. It gives off the following branches:—(*a*) **Pharyngeal,** which contributes to the supply of the roof of the pharynx, and anastomoses with the ascending pharyngeal and pterygo-palatine arteries; (*b*) **Eustachian,** which is distributed to the Eustachian tube; and (*c*) **tympanic,** which enters the tympanum, and anastomoses with the other tympanic arteries.

(5) The **pterygo-palatine artery,** or **pterygo-pharyngeal** as it is sometimes called, a still more slender branch than the Vidian, passes backwards through the pterygo-palatine foramen with the pharyngeal nerve, a branch of Meckel's ganglion. It divides into three branches:—(*a*) **Pharyngeal,** to the roof of the pharynx; (*b*) **Eustachian,** to the Eustachian tube; and (*c*) **sphenoidal,** to the sphenoidal cells. The pterygo-palatine sometimes arises from the spheno-palatine.

(6) The **spheno-palatine** or **naso-palatine artery,** the terminal branch of the internal maxillary, passes with the spheno-palatine branch of Meckel's ganglion from the spheno-maxillary fossa into the nose through the spheno-palatine foramen. Crossing the roof of the nose in the muco-periosteum, it passes on to the septum, and then runs forwards and downwards in a groove on the vomer (under the name of the **naso-palatine,** or **artery of the septum**) towards the anterior palatine foramen, where it anastomoses with the anterior palatine artery, which enters the nose through the lateral compartment of that foramen (the canal of Stenson). In this course it gives off the following branches:—(*a*) A **pharyngeal branch** (or **descending pharyngeal branch,** as it is sometimes called), which is distributed to the roof and contiguous portions of the pharynx. (*b*) A **sphenoidal branch,** which supplies the sphenoidal cells. (*c*) **Nasal branches,** which ramify over the turbinal bones and lateral walls of the nose, and give twigs to the ethmoidal and frontal sinuses and lining membrane of the antrum. (*d*) **Ascending septal**

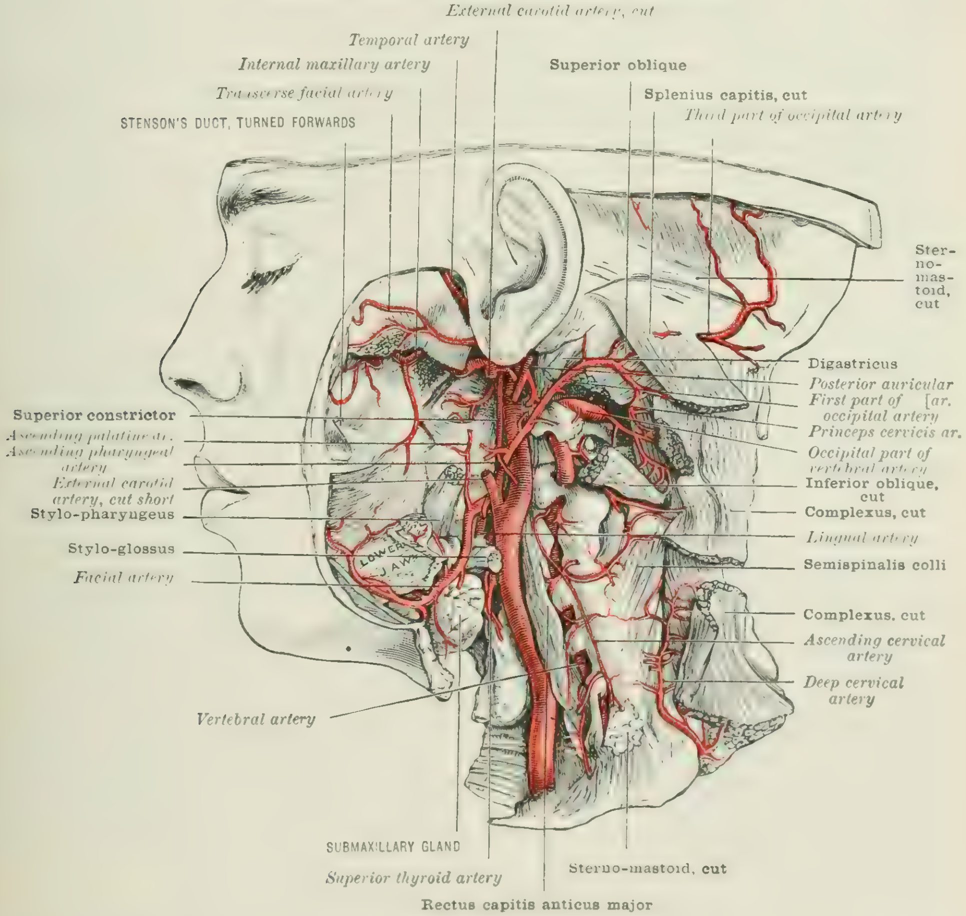
branches, which run upwards and forwards, giving small twigs to the mucous membrane covering the upper part of the septum, and which pass through the cribriform plate of the ethmoid, and anastomose with the ethmoidal arteries (**perforating** or **meningeal branches**).

THE INTERNAL CAROTID ARTERY

The **internal carotid** (fig. 338) arises with the external carotid at the bifurcation of the common carotid, opposite the upper border of the thyroid cartilage, on a level with the fourth cervical vertebra. It is at first placed a little external to the external carotid, but as it ascends in the neck the external carotid becomes more superficial and in front of the internal. The internal carotid passes up the neck, in front of the transverse processes of the upper cervical vertebræ lying upon the rectus capitis anticus major to the carotid foramen, thence through the carotid canal in the petrous portion of the temporal bone, making at first a turn forwards and inwards and then a second turn upwards, and enters the cranium through the foramen lacerum medium. It then makes a sigmoid curve on the side of the body of the sphenoid bone, and terminates, after perforating the dura mater, by

FIG. 338.—THE INTERNAL CAROTID ARTERY, AND DEEP BRANCHES OF THE EXTERNAL CAROTID ARTERY, LEFT SIDE.

(From a dissection in the Hunterian Museum.)


External carotid artery, cut
Temporal artery
Internal maxillary artery
Superior oblique
Transverse facial artery
Splenius capitis, cut
STENSON'S DUCT, TURNED FORWARDS
Third part of occipital artery
Sterno-mastoid, cut
Digastricus
Posterior auricular
First part of [ar.
occipital artery
Princeps cervicis ar.
Occipital part of
vertebral artery
Inferior oblique, cut
Complexus, cut
Lingual artery
Semispinalis colli
Complexus, cut
Ascending cervical artery
Deep cervical artery
Superior constrictor
Ascending palatine ar.
Ascending pharyngeal artery
External carotid artery, cut short
Stylo-pharyngeus
Stylo-glossus
Facial artery
LOWER JAW
Vertebral artery
SUBMAXILLARY GLAND
Superior thyroid artery
Sterno-mastoid, cut
Rectus capitis anticus major

dividing opposite the anterior clinoid processes in the fissure of Sylvius, into the anterior and middle cerebral arteries.

In its course up the neck it often forms one or more curves, especially in old people. Between the internal and the external carotids, at their angle of divergence, is situated the intercarotid body, or ganglion intercaroticum.

The internal carotid is the continuation upwards of the primitive dorsal aorta, and supplies the greater part of the brain, the contents of the orbit, and parts of the internal ear, forehead, and nose. It is divided into three portions:—1. a cervical; 2. an intraosseous, or petrosal; and 3. an intracranial.

1. The Cervical Portion

Relations.—In the neck the artery is at first comparatively superficial, having **in front** of it, as it lies in the superior carotid triangle, the skin, superficial fascia, platysma and deep fascia, and the overlapping edge of the sterno-mastoid muscle. Higher up, as it sinks beneath the parotid gland (fig. 329), it becomes deeply placed, and is crossed by the posterior belly of the digastric and stylo-hyoid muscles, the hypoglossal nerve, and the occipital and posterior auricular arteries; whilst still higher it is separated from the external carotid artery, which here gets in front of it, by the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the pneumogastric nerve, and by the stylo-hyoid ligament.

Behind, it lies upon the rectus capitis anticus major, which separates it from the transverse processes of the three upper cervical vertebræ, on the superior cervical ganglion of the sympathetic nerve, and on the pneumogastric nerve. Near the base of the skull, the hypoglossal, pneumogastric, glosso-pharyngeal, and spinal accessory nerves cross obliquely behind it, separating it at this spot from the internal jugular vein, which, as the artery is about to enter the carotid canal, also forms one of its posterior relations.

On its **outer side** are the internal jugular vein and pneumogastric nerve.

On its **inner side** it is in relation with the pharynx, the superior constrictor muscle separating it from the tonsil. The ascending pharyngeal and ascending palatine arteries, and at the base of the skull the Eustachian tube and levator palati muscle are also internal to it.

2. The Intraosseous or Petrosal Portion

The **intraosseous portion** (fig. 331) is situated in the carotid canal in the petrous portion of the temporal bone. It is here separated from the walls of the canal by a prolongation downwards of the dura mater. In this part of its course it first ascends in front of the tympanum and cochlea of the internal ear; it then turns forwards and inwards, lying a little internal to and behind the Eustachian tube, and enters the cranial cavity by turning upwards through the foramen lacerum medium, lying upon the lingula of the sphenoid bone. In this part of its course it is accompanied by the ascending branches from the superior cervical ganglion of the sympathetic. These form a plexus about the artery, but are situated chiefly on its outer side. It is also surrounded by a number of small veins, which receive tributaries from the tympanum, and open into the cavernous sinus and internal jugular vein.

3. The Intracranial Portion

On entering the cranium through the foramen lacerum medium, the internal carotid first ascends towards the posterior clinoid process, but soon changing its direction, it curves forwards and slightly downwards by the side of the body of the sphenoid bone on the inner wall of the cavernous sinus. Here it has the sixth nerve immediately external to it, and is covered by the lining membrane of the sinus. Again turning upwards, it pierces the dura mater on the inner side of the anterior clinoid process, and, passing between the second and third nerves to the anterior perforated spot at the inner end of the Sylvian fissure, divides into its two terminal branches, the anterior and middle cerebral. After it has perforated the dura mater, it is described by some anatomists as a fourth portion—the intracerebral (fig. 387). As it lies in the foramen lacerum medium the artery is crossed on its outer side by the great superficial petrosal nerve as the latter goes to join the great deep petrosal from the carotid plexus to form the Vidian nerve.

BRANCHES OF THE INTERNAL CAROTID ARTERY

The **cervical portion** gives off no branch. The **intraosseous portion** gives off:—(1) Tympanic; (2) Vidian. The **intracranial portion** gives off:—(1) Arteria receptaculi; (2) pituitary; (3) Gasserian; (4) meningeal; (5) ophthalmic; (6) posterior communicating; (7) anterior choroid; (8) anterior cerebral; (9) middle cerebral.

Branches of the Intraosseous Portion.—(1) The **tympanic** enters the tympanum through a small foramen in the posterior wall of the carotid canal, and contributes its quota to the blood-supply of that cavity. It anastomoses with the tympanic branches of the stylo-mastoid and internal maxillary arteries. (2) A **Vidian branch** is also described, and is said to anastomose with the Vidian artery.

Branches of the Intracranial Portion.—As the internal carotid artery lies on the inner side of the cavernous sinus, it gives off the following **branches**:—(1) **Arteria receptaculi,** small branches to the walls of the cavernous sinus; (2) **pituitary branches** to the pituitary body; (3) **Gasserian** or **ganglionic branches** to the Gasserian ganglion; (4) **meningeal** or **anterior meningeal branches** to the dura mater; these anastomose with anterior branches of the middle meningeal.

(5) THE OPHTHALMIC ARTERY

The **ophthalmic artery** (fig. 339) comes off from the internal carotid immediately below the anterior clinoid process just as the latter vessel is passing through the dura mater. Entering the orbit through the optic foramen below and external to the optic nerve, it at once perforates the sheath of dura mater which is prolonged through the optic foramen on both artery and nerve. It then runs in a gentle curve with its convexity outwards below the optic nerve and external rectus, being here crossed by the nasal nerve, and turning forwards, inwards, and upwards, passes over the optic nerve, round which it thus forms a loop (fig. 339) to the inner side of the orbit. Thence it runs obliquely beneath the superior rectus in front of the nasal nerve under the lower border of the superior oblique, but above the internal rectus, and continues its course under the pulley for the superior oblique and reflected tendon of that muscle to the internal angular process of the orbit, where it divides into the frontal and nasal branches.

BRANCHES OF THE OPHTHALMIC ARTERY

The **branches of the ophthalmic artery** are:—(*a*) the lachrymal; (*b*) the supra-orbital; (*c*) the central artery of the retina; (*d*) the muscular; (*e*) the ciliary; (*f*) the posterior ethmoidal; (*g*) the anterior ethmoidal; (*h*) the palpebral; (*i*) the frontal; and (*k*) the nasal.

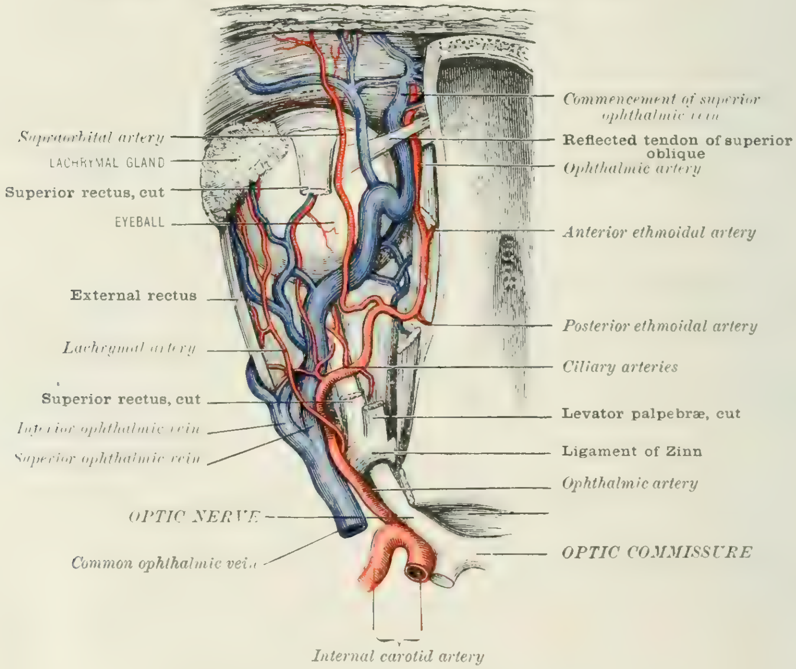
(*a*) THE LACHRYMAL ARTERY

The **lachrymal artery** is usually the first and at times the largest branch of the ophthalmic. It arises between the superior and external rectus on the outer side of the optic nerve from the ophthalmic soon after that vessel has entered the orbit. At times it is given off from the ophthalmic outside the orbit, and then usually passes into that cavity through the sphenoidal fissure. It runs forwards along the outer wall of the orbit with the lachrymal nerve above the upper border of the external rectus to the lachrymal gland, which it supplies. In this course it furnishes the following branches:—(i) **Recurrent lachrymal,** one or more branches which pass backwards through the sphenoidal fissure, and anastomoses with the lachrymal branch of the large middle meningeal artery. The anastomosis is sometimes of large size, and takes the chief share in the formation of the lachrymal artery. (ii) **Muscular branches,** distributed chiefly to the external rectus. (iii) **Malar branches**—small twigs, which pass through the malar canals, and anastomose with the orbital branch of the middle temporal, and with the transverse facial on the cheek. (iv) **Palpebral branches,** which are distributed to the upper and lower eyelids and to the conjunctiva. (v) **Ciliary.** See CILIARY ARTERIES, page 501.

(*b*) THE SUPRAORBITAL ARTERY

The **supraorbital artery** usually arises from the ophthalmic as the latter vessel is about to cross over the optic nerve. Passing upwards to the inner side of the superior rectus and levator palpebræ, it runs along the upper surface of the latter muscle with the frontal nerve in the orbital fat, but beneath the periosteum to the supraorbital notch. On emerging on the forehead beneath the orbicularis palpebrarum, it divides into a superficial and deep branch; the former ramifies between the skin and occipito-frontalis, the latter between the occipito-frontalis and the pericranium. Both branches anastomose with the anterior branches of the superficial temporal, the angular branch of the facial, and the transverse facial artery. The branches of the supraorbital are:—(i) **Periosteal,** to the periosteum of the roof of the orbit; (ii) **muscular,** to the levator palpebræ and superior rectus; (iii) **diploic,** given off as the artery is passing through the supraorbital notch and entering a minute foramen at the bottom of the notch is distributed to the diploë and frontal sinuses; (iv) **trochlear,** to the pulley of the superior oblique; (v) **palpebral,** to the upper eyelid.

FIG. 339.—THE LEFT OPHTHALMIC ARTERY AND VEIN.


Supraorbital artery
LACHRYMAL GLAND
Superior rectus, cut
EYEBALL
External rectus
Lachrymal artery
Superior rectus, cut
Inferior ophthalmic vein
Superior ophthalmic vein
OPTIC NERVE
Common ophthalmic vein
Commencement of superior ophthalmic vein
Reflected tendon of superior oblique
Ophthalmic artery
Anterior ethmoidal artery
Posterior ethmoidal artery
Ciliary arteries
Levator palpebræ, cut
Ligament of Zinn
Ophthalmic artery
OPTIC COMMISSURE
Internal carotid artery

(*c*) THE CENTRAL ARTERY OF THE RETINA

The **arteria centralis retinæ**, a small but constant branch, comes off from the ophthalmic close to the optic foramen, and, perforating the optic nerve about a quarter of an inch behind the globe, runs forwards in the substance of the nerve to the eyeball, supplying the retina. The fact that this artery penetrates the substance of the optic nerve is of developmental interest, as it indicates the spot where the mesenchyma invaginated the primary optic vesicle on its ventral aspect to form the vitreous. Its further description is given in the ANATOMY OF THE EYE.

(*d*) THE MUSCULAR BRANCHES

The **muscular branches** are very variable in their origin and distribution. They may be roughly divided into superior and inferior sets. The superior or smaller set supply the superior oblique, the levator palpebræ, and superior rectus. The inferior pass forward between the optic nerve and the inferior rectus, supplying that muscle, the internal rectus, and the inferior oblique. From the muscular branches are given off the anterior ciliary arteries. (See CILIARY ARTERIES.)

(*e*) THE CILIARY ARTERIES

The **ciliary arteries** are divided into three sets:—The **short posterior,** the **long posterior,** and the **anterior.** (i) The **short posterior,** five to six in number, come off chiefly from the ophthalmic as it is crossing the optic nerve. They run forwards about the nerve, dividing into twelve or fifteen small vessels, which perforate the sclerotic around the entrance of the optic nerve, and are distributed to the choroid coat. (ii) The **long posterior** ciliary arteries, usually two in number, come off from the ophthalmic on either side of the optic nerve, and run forwards with the short ciliary to the sclerotic. On piercing the sclerotic, they course forwards, one on either side in the equatorial line, between that coat and the choroid to the ciliary processes and iris. Their further distribution is given under the ANATOMY OF THE EYE. (iii) The **anterior ciliary** are derived from the muscular branches and from the lachrymal. They run to the globe along the tendons of the recti, forming a zone of radiating vessels beneath the conjunctiva. They perforate the sclerotic about a quarter of an inch (6 mm.) behind the cornea, and supply the iris and ciliary processes. It is these vessels that are enlarged and congested in iritis, forming the circumcorneal zone of redness so characteristic of that disease. They then differ from the tortuous vessels of the conjunctiva in that they are straight and parallel.

(*f*) THE POSTERIOR ETHMOIDAL ARTERY

The **posterior ethmoidal** runs inwards between the superior oblique and internal rectus, and, leaving the orbit by the posterior ethmoidal canal, together with the spheno-ethmoidal branch of the nasal nerve, enters the posterior ethmoidal cells, whence it passes through a transverse slit-like aperture between the sphenoid bone and cribriform plate of the ethmoid bone into the cranium. It gives off (i) **ethmoidal branches** to the posterior ethmoidal cells; (ii) **meningeal branches** to the dura mater lining the cribriform plate; and (iii) **nasal branches,** which pass through the cribriform plate to the superior meatus and upper spongy bones of the nose, and anastomose with the nasal branches of the spheno-palatine artery.

(*g*) THE ANTERIOR ETHMOIDAL ARTERY

The **anterior ethmoidal** (figs. 339, 387), a larger branch than the posterior ethmoidal, arises in front of the latter, passes inwards between the superior oblique and internal rectus, and, leaving the orbit through the anterior ethmoidal canal, in company with the nasal nerve, enters the cranial cavity. After running a short distance beneath the dura mater on the cribriform plate of the ethmoid bone, it passes into the nose through the horizontal slit-like aperture by the side of the crista galli. Its terminal branch passes along the groove on the under surface of the nasal bone, and emerges on the nose between the bone and lateral cartilage, terminating in the skin of that organ. It gives off the following branches in its course:—(i) **Ethmoidal,** to the anterior ethmoidal cells; (ii) **meningeal,** to the dura mater of the anterior fossa; (iii) **nasal,** to the middle meatus and anterior part of the nose; (iv) **frontal,** to the frontal sinuses; (v) **cutaneous,** or **terminal,** to the skin of the nose.

(*h*) THE PALPEBRAL BRANCHES

The **palpebral branches** arise either separately or by a common trunk from the ophthalmic artery opposite the pulley for the superior oblique, just as the latter vessel is about to divide into its terminal branches. They pass, one above and one below the internal tarsal ligament or tendo oculi, and then skirt along the upper and lower eyelids respectively, near the free margin between the tarsal cartilages and the orbicularis muscle, and form a superior and inferior palpebral arch by anastomosing with the palpebral branches of the lachrymal. The upper also anastomoses with the supraorbital artery and orbital branch of the temporal artery; the lower with the infraorbital, the angular branch of the facial, and the transverse facial arteries. A branch from the lower palpebral passes with the nasal duct as far as the inferior meatus. Small twigs are also given to the caruncle and conjunctiva.

(*i*) THE FRONTAL BRANCH

The **frontal branch,** the upper of the terminal branches of the ophthalmic, pierces the tarsal membrane at the inner angle of the orbit, passes upwards over the frontal bone, beneath the orbicularis palpebrarum and corrugator supercilii, supplies the structures in its neighbourhood, and anastomoses with its fellow of the opposite side, with the supraorbital, and with the anterior division of the superficial temporal artery.

(*k*) THE NASAL BRANCH

The **nasal,** the lower of the terminal branches of the ophthalmic, leaves the orbit at the inner canthus by perforating the tarsal membrane above the tendo oculi. It then descends along the dorsum of the nose, beneath the integuments; and anastomoses with the angular and lateral nasal branches of the facial. It gives off a **lachrymal branch** as it crosses the lachrymal sac, and a **transverse nasal branch** as it crosses the root of the nose; the latter vessel anastomoses with its fellow of the opposite side.

(6) THE POSTERIOR COMMUNICATING ARTERY

The **posterior communicating artery** (fig. 340) is given off from the internal carotid just before the division of that vessel into the anterior and middle cerebral arteries; occasionally it arises from the middle cerebral itself. It is as a rule a slender vessel which runs backwards over the optic tract and crus cerebri along the side of the uncinate convolution to join the posterior cerebral. At times, however, it is of considerable size, and contributes chiefly to form the posterior cerebral, the portion of the latter vessel between the basilar and posterior communicating being then as a rule reduced to a mere rudiment. It gives off the following branches:—(*a*) the **uncinate,** to the convolution of that name; and (*b*) the **middle thalamic,** to the optic thalamus.

(7) THE ANTERIOR CHOROID ARTERY

The **anterior choroid** is a small but constant vessel, which arises as a rule from the back part of the internal carotid just external to the origin of the posterior communicating. It passes backwards on the optic tract and the crus cerebri, at first lying parallel and a little external to the posterior communicating artery, and then, turning slightly outwards, dips under the edge of the uncinate convolution, and, entering the transverse fissure at the lower end of the descending cornu of the lateral ventricle, ends in the choroid plexus and supplies the hippocampus major and corpus fimbriatum.

(8) THE ANTERIOR CEREBRAL ARTERY

The **anterior cerebral artery** (fig. 340)—one of the terminal branches into which the internal carotid divides in the fissure of Sylvius—passes at first forwards and inwards across the anterior perforated space between the olfactory and optic nerves to the longitudinal fissure where it approaches its fellow of the opposite side, and communicates with it by a short transverse trunk, about two lines long, known as the **anterior communicating artery.** Onwards from this spot it runs side by side with its fellow in the longitudinal fissure round the genu of the corpus callosum; then, turning backwards, it continues along the upper surface of that commissure, and, after giving off large branches to the frontal and parietal lobules, anastomoses with the posterior cerebral artery.

The **branches of the anterior cerebral** are:—(*a*) Communicating; (*b*) ganglionic, or central; (*c*) commissural; (*d*) hemispheral, or cortical.

(*a*) **Communicating.**—The **anterior communicating** is a transverse trunk about two lines in length, connecting the right and left anterior cerebral arteries. It lies immediately in front of the optic commissure across the lamina cinerea. It gives off some of the **antero-median branches** which pass from the anterior cerebral to the fore end of the caudate nucleus. Sometimes the anterior cerebral arteries, instead of communicating by a transverse trunk, coalesce for a short distance and then again divide. Upon this short trunk the terminal filaments of the carotid plexus of the sympathetic of either side meet in a small gangliform enlargement known as the 'ganglion of Ribes.'

(*b*) **Ganglionic, or central.**—The **antero-median group,** together with the antero-median branches of the anterior communicating, pass through the lamina cinerea and supply the fore end of the caudate nucleus.

(*c*) **Commissural.**—These supply the corpus callosum.

(*d*) **The hemispheral or cortical branches.**—(i) The **orbital,** three or four in number, supply the inferior surface of the first frontal convolution, and give off small twigs to the olfactory bulb. (ii) The **margino-frontal** arise from the artery as it lies on the corpus callosum, and, after supplying the marginal convolution, pass on to the convex surface of the hemisphere and further supply the first and second frontal convolutions and the upper part of the ascending frontal convolution. (iii) The **calloso-marginal** supplies the callosal convolution and the upper part of the marginal convolution. (iv) The **quadrate** is a branch to the convolution of that name.

(9) THE MIDDLE CEREBRAL ARTERY

The **middle cerebral artery** (fig. 340)—the larger of the two terminal divisions of the internal carotid—passes obliquely upwards and outwards into the fissure of Sylvius, and opposite the insula or island of Reil divides into its hemispheral or cortical branches.

The **branches of the middle cerebral** are:—(*a*) Ganglionic, or central; and (*b*) hemispheral, or cortical.

(*a*) **Ganglionic, or central.**—(i) The **caudate** are two or three small branches, which arise from the inner aspect of the artery and pass through the inner part of the floor of the fissure of Sylvius to the head of the caudate nucleus. (ii) The **antero-lateral** are numerous small arteries, which pass through the anterior perforated space and supply the caudate nucleus (except its head), the internal capsule, and part of the optic thalamus. (iii) The **lenticulo-striate,** a larger branch of the antero-lateral set, passes through a separate hole in the outer part of the anterior perforated space, runs upwards between the lenticular nucleus (which it supplies) and the external capsule, perforates the internal capsule, and terminates in the caudate nucleus. It has been so frequently found ruptured in apoplexy, that it is called by Charcot the 'artery of cerebral hæmorrhage.' (iv) Sometimes a more or less distinct branch, called **lenticulo-optic,** is distributed to the outer and hinder portion of the lenticular nucleus and the external portion of the thalamus opticus.

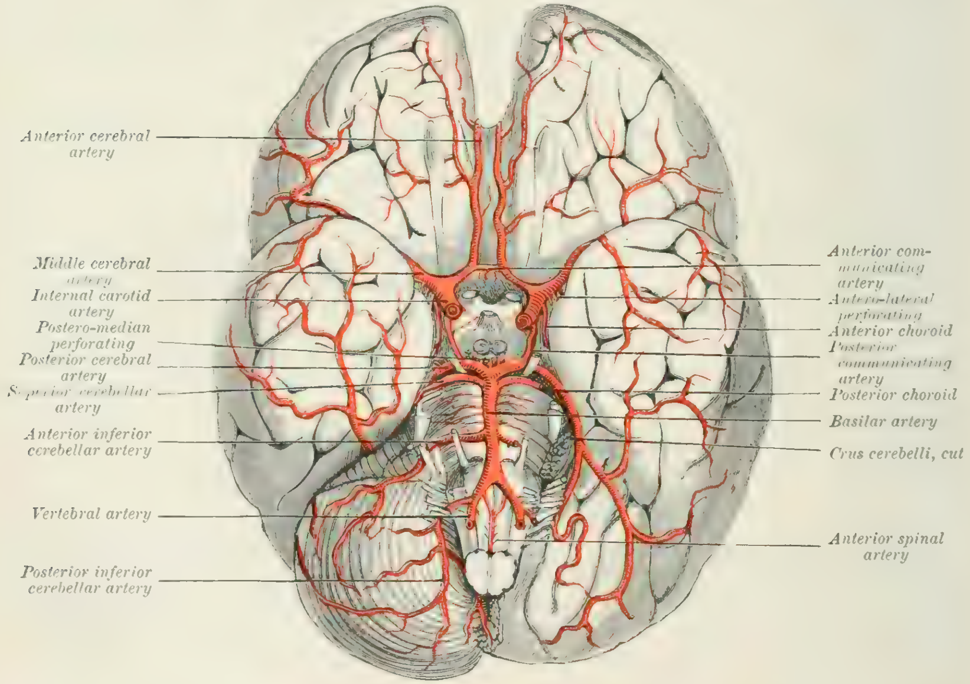
(*b*) The **hemispheral** or **cortical branches** come off from the middle cerebral opposite the insula. They are four in number:—(i) The **inferior,** or **orbito-frontal,** to the inferior frontal convolutions. (ii) The **ascending frontal,** to the lower part of the ascending frontal convolution, the upper part being supplied by the margino-frontal, a branch of the anterior cerebral. (iii) The **parietal,** to the whole of the ascending parietal and the adjacent part of the inferior parietal convolution. (iv) The **parieto-temporal,** to the convolutions around the posterior limb of the fissure of Sylvius—viz. the supra-marginal, the angular, and the posterior part of the inferior parietal above, and the first and the greater part of the second and third temporal below.

The Circle of Willis

The anastomosis of the branches of the internal carotid and vertebral arteries at the base of the brain is known as the circle of Willis (fig. 340). This so-called circle, which has really the form of a heptagon, is formed, **in front,** by the anterior communicating artery uniting the anterior cerebral arteries of opposite sides; **laterally,** by the trunk of the internal carotid and the posterior communicating arteries stretching between it and the posterior cerebral; **behind,** by the two posterior cerebrals diverging from the bifurcation of the basilar artery (page 543). This free anastomosis between the two internal carotid and the two vertebral arteries serves to equalise the flow of blood to the various portions of the brain; and, should one or more of the arteries entering into the formation of the circle be temporarily or permanently obstructed, it ensures a flow of blood to the otherwise deprived part through some of the collateral arteries. Thus, if one carotid or one vertebral is obstructed, the parts supplied by that vessel receive their blood through the circle from the remaining pervious vessels. Indeed, one vertebral artery alone has been found equal to the task of carrying sufficient blood for the supply of the

Fig. 340.—The Arteries of the Brain.

(The posterior part of the cerebrum on the left side has been cut away to show the cerebellum. From a preparation in the Museum of St. Bartholomew's Hospital.)


Anterior cerebral artery
Middle cerebral artery
Internal carotid artery
Postero-median perforating
Posterior cerebral artery
Superior cerebellar artery
Anterior inferior cerebellar artery
Vertebral artery
Posterior inferior cerebellar artery
Anterior communicating artery
Antero-lateral perforating
Anterior choroid
Posterior communicating artery
Posterior choroid
Basilar artery
Crus cerebelli, cut
Anterior spinal artery

brain after ligature of both the carotids and the other vertebral artery. Further, the circle of Willis is the only medium of communication between the ganglionic or central and the hemispheral or cortical branches of the cerebral arteries, and between the various ganglionic branches themselves. The ganglionic and the cortical branches form separate and distinct systems, and do not anastomose with each other; and the ganglionic, moreover, are so-called end-vessels, and do not anastomose with the neighbouring ganglionic branches.

THE SUBCLAVIAN ARTERY

The **subclavian artery** on the right side arises at the bifurcation of the innominate behind the right sterno-clavicular articulation. On the left side it arises from the arch of the aorta, and as far as the inner border of the scalenus anticus is situated deeply in the chest. The first portion of the left subclavian artery is described separately.

Beyond the inner border of the scalenus anticus the artery has the same relations on both sides. It courses from this point beneath the clavicle in a slight curve across the root of the neck to the outer border of the first rib, there to end in the axillary artery. Thus the course of the artery in the neck will be indicated by a line drawn from the sterno-clavicular joint in a curve with its convexity upwards to the middle of the clavicle. The height the artery rises in the neck varies. It is perhaps most commonly about half an inch above the clavicle. If the curved line above mentioned is drawn to represent part of the circumference of a circle having its centre at a point on the lower margin of the clavicle an inch and a half from the sternal end of that bone, the line of the artery will be sufficiently well indicated for all practical purposes. In its course the artery arches over the dome of the pleura and gains the groove on the upper surface of the first rib by passing between the scalenus anticus and medius muscles. The artery is accompanied by the subclavian vein, the latter vessel lying in front of the scalenus anticus, anterior to the artery, and on a slightly lower plane.

The subclavian artery is divided into three portions—as it lies internal to, behind, or external to, the scalenus anticus muscle.

THE FIRST OR THORACIC PORTION OF THE LEFT SUBCLAVIAN ARTERY

The **left subclavian artery** (fig. 328) arises from the termination of the transverse portion of the arch of the aorta. The first part of the left subclavian is consequently longer than the first part of the right, which arises at the bifurcation of the innominate opposite the right sterno-clavicular joint. The artery at its origin is situated deeply in the thorax, and as it arises from the aorta is on a plane posterior to and a little to the left of the thoracic portion of the left common carotid. It first ascends almost vertically out of the chest, and at the root of the neck curves outwards over the apex of the left pleura and lung to the interval between the anterior and middle scalene muscles. Beyond the inner border of the scalenus anticus—that is, in the second and third portions of its course—its relations are similar to those of the right subclavian artery.

Relations.—In front it is covered by the left pleura and lung, whilst more superficial are the sterno-thyroid, sterno-hyoid, and sterno-mastoid muscles. It is crossed a little above its origin by the left innominate vein, and higher in the neck near the scalenus anticus by the internal jugular, vertebral, and subclavian veins. The phrenic nerve crosses the artery immediately internal to the scalenus anticus, and then descends parallel to it but on an anterior plane to cross the arch of the aorta. The pneumogastric nerve descends parallel to the artery between it and the left common carotid, coming into contact with its anterior surface just before crossing the arch of the aorta. The left cervical cardiac nerves of the sympathetic also descend in front of it on their way to the cardiac plexus. The left common carotid is situated anteriorly and to its right. The thoracic duct arches over the artery just internal to the scalenus anticus, to empty its contents into the confluence of the internal jugular and subclavian veins (fig. 360).

Behind and somewhat internal to it are the œsophagus, thoracic duct, inferior cervical ganglion of the sympathetic, longus colli muscle, and vertebral column. To some extent it is overlapped posteriorly by the left pleura and lung (fig. 328).

On its **right side** are the trachea and the recurrent laryngeal nerve, and, higher up, the œsophagus and thoracic duct.

On its **left side** are the left pleura and lung.

The chief variations in the origin of the left subclavian artery are given under VARIATIONS OF THE ARCH OF THE AORTA (page 472).

THE FIRST PORTION OF THE RIGHT SUBCLAVIAN ARTERY

The **first portion of the right subclavian artery** extends from its origin at the bifurcation of the innominate, behind the upper margin of the right sterno-clavicular joint, upwards and outwards in a gentle curve over the apex of the right lung and pleura to the inner border of the scalenus anticus. It measures about one inch and a quarter in length (3 cm.). In this course it ascends in the neck a variable distance above the clavicle, but is so deeply placed, so surrounded by important structures, and gives off so many large branches, that it is now seldom or never selected for the application of a ligature.

Relations.—In front it is covered by the integuments, the superficial fascia, the platysma, the anterior layer of the deep fascia, the clavicular origin of the sterno-mastoid, the sterno-hyoid and sterno-thyroid muscles, and the deep cervical fascia. It is crossed by the commencement of the innominate, by the internal jugular, and by the vertebral veins; and from within outwards by the pneumogastric and phrenic nerves, and the superior cardiac branches of the sympathetic nerve. A loop of the sympathetic nerve itself also crosses the artery, and forms with the trunk of the sympathetic a ring around the vessel known as the annulus of Vieussens.

Behind, but separated from the artery by a cellular interval, are the longus colli muscle, the transverse process of the seventh cervical or first thoracic vertebra, the main chain of the sympathetic nerve, the inferior cardiac nerves, the recurrent laryngeal nerve, and the apex of the right lung and pleura.

Below, it is in contact with the pleura and lung and the loop of the recurrent laryngeal nerve, which winds round the artery from the pneumogastric and ascends behind it to the larynx. The subclavian vein is below the artery and on an anterior plane.

Branches.—The vertebral, internal mammary, and thyroid axis arise from this part of the vessel. Not uncommonly a small aberrant artery also takes origin from this portion of the artery and descends to the left behind the œsophagus to join a branch of the aorta opposite the third or fourth thoracic vertebra. This vessel is probably the remains of the right aortic root.

THE SECOND PORTION OF THE SUBCLAVIAN ARTERY

The **second portion of the subclavian artery** lies behind the scalenus anticus muscle. It measures about three-quarters of an inch in length (2 cm.), and here reaches highest in the neck. The subclavian vein is separated from the artery by the scalenus anticus, and lies on a lower and anterior plane.

Relations.—In front it is covered by the skin, superficial fascia, platysma, anterior layer of deep fascia, the clavicular origin of the sterno-mastoid, posterior layer of deep fascia, and by the scalenus anticus. The phrenic nerve—which, in consequence of its oblique course downwards and inwards, crosses a portion of both the first and second part of the subclavian—is separated from the second portion by the scalenus anticus muscle as is also the subclavian vein which courses on a somewhat lower plane.

Behind the artery are the apex of the pleura and lung, and a portion of the scalenus medius; also the structure known as Sibson's fascia.

Above is the brachial plexus.

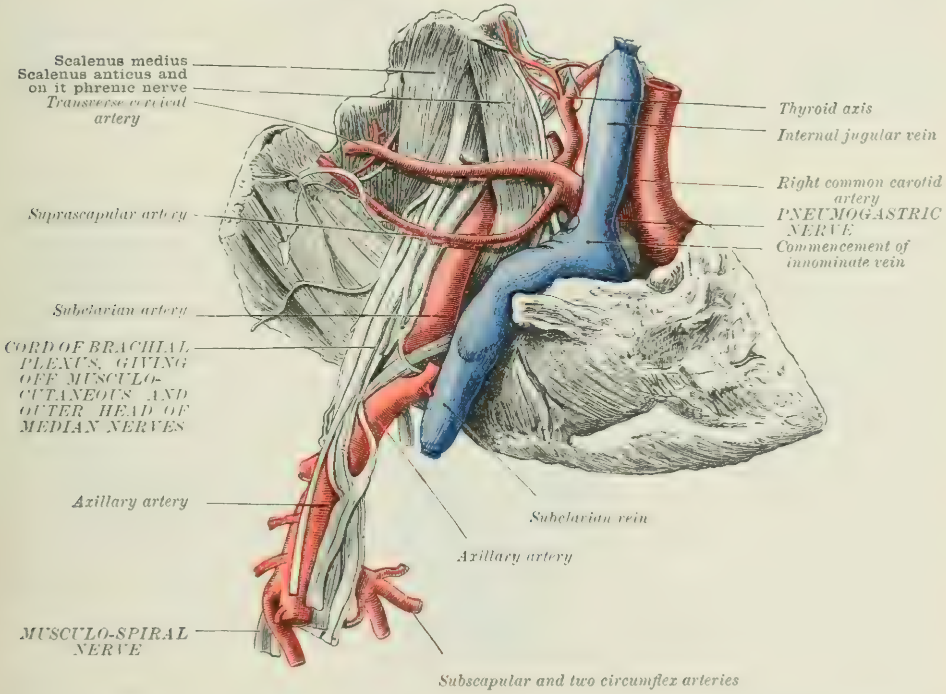
Below are the pleura and lung.

One **branch** only—the superior intercostal—is, as a rule, given off from this portion of the subclavian; occasionally the posterior scapular artery arises from it.

THE THIRD PORTION OF THE SUBCLAVIAN ARTERY

The **third portion of the subclavian artery** extends from the outer margin of the scalenus anticus muscle, downwards and outwards to the outer border of the first rib. It is more superficial than either the first or second portions; it is in relation with less important structures, and as a rule gives off no branch, and for these reasons is the part selected when practicable for the application of a ligature. It is the longest of the three portions of the subclavian artery, and lies in a triangle—the subclavian triangle—bounded by the sterno-mastoid, the omo-hyoid, and the clavicle.

FIG. 341.—THE RIGHT SUBCLAVIAN ARTERY.


Scalenus medius
Scalenus anticus and on it phrenic nerve
Transverse cervical artery
Suprascapular artery
Subclavian artery
CORD OF BRACHIAL PLEXUS, GIVING OFF MUSCULO-CUTANEOUS AND OUTER HEAD OF MEDIAN NERVES
Axillary artery
MUSCULO-SPIRAL NERVE
Thyroid axis
Internal jugular vein
Right common carotid artery
PNEUMOGASTRIC NERVE
Commencement of innominate vein
Subclavian vein
Axillary artery
Subscapular and two circumflex arteries

Relations.—In front it is covered by the skin, superficial fascia, platysma, clavicular branches of the descending portion of the superficial cervical plexus of nerves; anterior layer of deep fascia which descends from the omo-hyoid to the clavicle; and the posterior layer of deep fascia which descends from the omo-hyoid to the first rib and is prolonged inwards over the scalenus anticus and phrenic nerve. Between the two layers of fascia is a variable amount of cellular tissue and fat, and running in this is the suprascapular artery. The subclavian is crossed by this artery unless the arm is drawn well downwards. Hence one of the reasons for depressing the shoulder, and thus avoiding the suprascapular artery, in the operation of ligaturing the subclavian. Close to the outer margin of the sterno-mastoid, the external jugular vein pierces the fascia, and crosses the subclavian artery to open into the subclavian vein. As this vein lies between the two layers of fascia, it receives on its external side the suprascapular, transverse cervical, and other veins of the neck, which together form a plexus of large veins in front of the artery. The nerve to the subclavius, and when present the accessory branch from this nerve to the phrenic, also here cross in front of the artery. In very muscular subjects the sterno-mastoid may extend further outwards along the clavicle than usual, and in such a case will form one of the coverings of the artery.

Behind, the artery is in contact with the scalenus medius, and with the cord of the brachial plexus formed by the union of the eighth cervical and first dorsal nerve.

Below, the artery rests in the posterior of the two grooves on the upper surface of the first rib.

Above is the brachial plexus of nerves and the posterior belly of the omo-hyoid muscle. The cord formed by the fifth and sixth cervical nerves is also above the artery, but on a somewhat anterior plane. It is close to the vessel, and has been mistaken for the artery in the application of a ligature.

As a rule there is no branch given off from the third portion of the subclavian. At times, however, the suprascapular (fig. 329) or the posterior scapular artery may arise from the third portion of the subclavian, instead of from the thyroid axis and from the transverse cervical respectively as here described.

Chief Variations in the Subclavian Artery

(A) The right subclavian artery may arise directly from the arch of the aorta, and then come off as the first, second, third or fourth branch of that vessel. When it arises as the first branch, it takes the place usually occupied by the innominate; when it arises as the last branch, it courses behind the trachea and œsophagus to gain the groove on the first rib. As the second or third branch of the aortic arch it is very rare; in both instances it then runs behind the right common carotid. The explanation of the right subclavian arising as the last branch of the arch of the aorta, is that the right aortic arch has remained pervious, whilst the normal root of the subclavian artery has become obliterated. An arteria aberrans, given off from the right subclavian or from the superior intercostal, can generally be traced to the third thoracic vertebra behind the œsophagus, and in a number of such cases can be followed across the spine to anastomose with a branch of the thoracic aorta given off below the ductus arteriosus. It is the enlargement of this anastomosis—which is itself the remains of what was the primitive right dorsal aorta in the embryo—that gives rise to the abnormality in question. The inferior laryngeal nerve in such cases, in consequence of the right fourth arch which forms the first portion of the subclavian being obliterated, follows a direct course to the larynx instead of winding recurrently round the subclavian artery.

(B) The right subclavian may arise higher or lower in the neck than usual, according as the innominate divides above or below the normal situation.

(C) It may perforate the scalenus anticus or pass in front of that muscle.

(D) It may ascend as high as an inch and a half above the clavicle, or remain below the level of that bone.

(E) The third part of the artery may be covered by the trapezius or sterno-mastoid, or by a clavicular origin of the omo-hyoid.

(F) The subclavian vein may accompany the artery behind the scalenus anticus.

BRANCHES OF THE SUBCLAVIAN ARTERY

From the **first portion** of the subclavian artery are given off: from the upper and back part and about three-quarters of an inch (2 cm.) from its origin, the **vertebral**; a little further outwards, from the front part, the **thyroid axis**; and from the lower part—usually opposite the thyroid axis, or else between the thyroid axis and the vertebral—the **internal mammary.**

From the **second portion** arises, from the back of the vessel, the **superior intercostal.**

The **third portion** as a rule, gives off no branch.

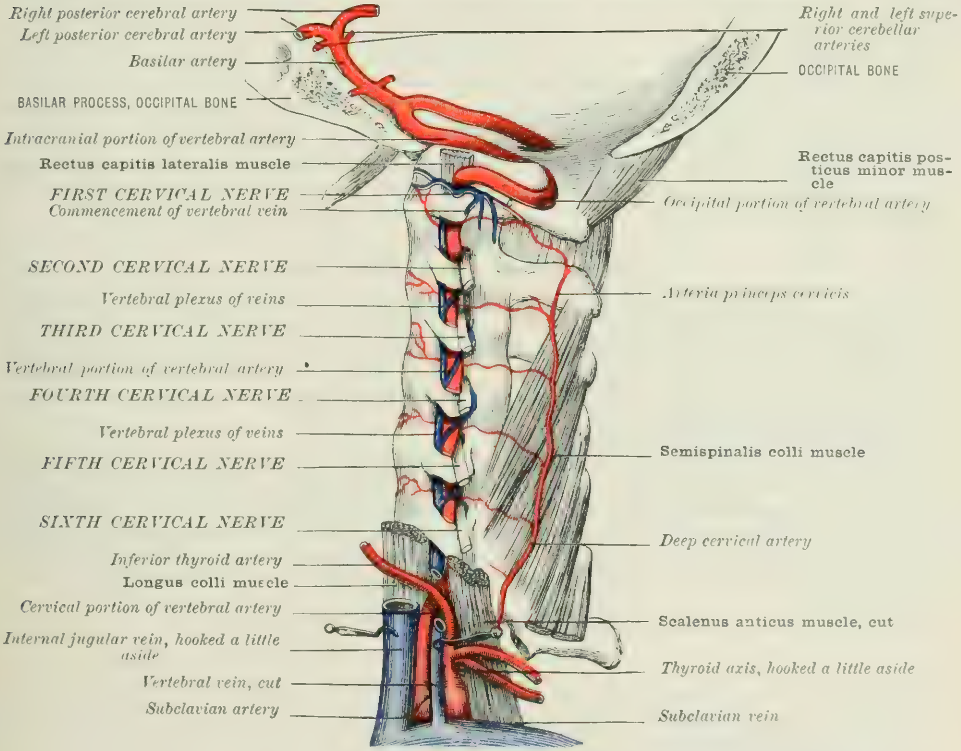
Branches of the First Part of the Subclavian Artery

THE VERTEBRAL ARTERY

The **vertebral artery,** the first and largest branch, arises from the upper and posterior part of the first portion of the subclavian, on the right side about three-quarters of an inch (2 cm.) from the origin of the latter vessel from the innominate, on the left side, from the most prominent part of the arch of the subclavian, close to the inner edge of the scalenus anticus muscle. It first ascends to the foramen in the costo-transverse process of the sixth cervical vertebra, and, having passed through that foramen and those of the next succeeding cervical vertebræ as high as the axis, it turns outwards and then upwards to reach the foramen in the transverse process of the atlas; after passing through that foramen it turns backwards behind the articular process lying in the groove on the posterior arch of the atlas. It next pierces the posterior occipito-atloid ligament and the dura mater, and enters the cranium through the foramen magnum. Here it passes upwards, at first lying by the side of the medulla, then in front of that structure, and terminates at the lower portion of the pons by inosculating with the vertebral of the opposite side to form the basilar.

Fig. 342.—Scheme of the Left Vertebral Artery. (Walsham.)

The internal jugular and vertebral veins are hooked aside to expose the artery.


Right posterior cerebral artery
Left posterior cerebral artery
Basilar artery
BASILAR PROCESS, OCCIPITAL BONE
Intracranial portion of vertebral artery
Rectus capitis lateralis muscle
FIRST CERVICAL NERVE
Commencement of vertebral vein
SECOND CERVICAL NERVE
Vertebral plexus of veins
THIRD CERVICAL NERVE
Vertebral portion of vertebral artery
FOURTH CERVICAL NERVE
Vertebral plexus of veins
FIFTH CERVICAL NERVE
SIXTH CERVICAL NERVE
Inferior thyroid artery
Longus colli muscle
Cervical portion of vertebral artery
Internal jugular vein, hooked a little aside
Vertebral vein, cut
Subclavian artery
Right and left superior cerebellar arteries
OCCIPITAL BONE
Rectus capitis posticus minor muscle
Occipital portion of vertebral artery
Arteria princeps cervicis
Semispinalis colli muscle
Deep cervical artery
Scalenus anticus muscle, cut
Thyroid axis, hooked a little aside
Subclavian vein

The vertebral artery may be divided for purposes of description into four parts: the **first,** or **cervical,** extending from its origin to the transverse process of the sixth cervical vertebra; the **second,** or **vertebral,** situated in the intervertebral foramina; the **third,** or **occipital,** contained in the suboccipital triangle; and the **fourth,** or **intracranial,** within the cranium.

The first or cervical portion.—The artery here lies between the scalenus anticus and longus colli muscles. **In front** it is covered by the vertebral and internal jugular veins, and is crossed by the inferior thyroid artery; and on the left side, in addition, by the thoracic duct, which runs over it from within outwards. **Behind,** the artery lies on the transverse process of the seventh cervical vertebra and the sympathetic nerve. To its **inner side** is the longus colli. To its **outer side** is the scalenus anticus. It gives off as a rule no branch in this part of its course. Occasionally, however, a small branch passes into the foramen of the transverse process of the seventh cervical vertebra.

The second or vertebral portion.—As the artery passes through the intervertebral foramina, it is surrounded by a plexus of veins and by branches of the sympathetic nerve. The cervical nerves lie behind it. Between the transverse processes it is in contact with the intertransverse muscles.

The third or occipital portion.—The artery here lies in the suboccipital triangle, bounded by the superior oblique, inferior oblique, and rectus capitis posticus major muscles. As it winds round the groove on the atlas, it has the rectus capitis lateralis, the articular process, and the occipito-atloid ligament **in front** of it; the superior oblique, the rectus capitis posticus major and the complexus **behind** it. Separating it from the arch of the atlas, is the first cervical or suboccipital nerve.

The **fourth** or **intracranial portion** extends from the aperture in the dura mater to the lower border of the pons, where it unites with its fellow to form the basilar artery. It here winds round from the side to the front of the medulla, lying in the vertebral groove on the basilar process of the occipital bone. In this course it passes beneath the first process of the ligamentum dentatum, and between the hypoglossal nerve in front, and the anterior roots of the suboccipital nerve behind.

Chief Variations of the Vertebral Artery

(A) The right vertebral artery may arise from the first part of the subclavian, either nearer to the innominate, or nearer to the anterior scalene muscle than normal.

(B) It may come off from the arch of the aorta direct. (See VARIATIONS IN THE CHIEF BRANCHES OF THE ARCH OF THE AORTA.)

(C) It may arise from the right common carotid when the right subclavian is given off from the aorta beyond the left subclavian.

(D) It may pass behind the œsophagus.

(E) The left vertebral artery may also arise from the arch of the aorta direct, or from the left common carotid. (See VARIATIONS IN THE CHIEF BRANCHES OF THE AORTA.)

(F) Either vertebral may enter the foramen in the seventh cervical vertebra, or in that of the fifth, fourth, third, or second. When entering one of the higher vertebral foramina, it may lie behind the common carotid and cause some embarrassment in the ligature of the latter vessel.

(G) Either vertebral may give off the inferior thyroid, superior intercostal, deep cervical, or occipital artery.

(H) One or other artery may be much increased or diminished in size.

BRANCHES OF THE VERTEBRAL ARTERY

A. **Cervical portion.**—No branch.

B. **Vertebral portion.**—1. Lateral spinal; 2. muscular.

C. **Occipital portion.**—1. Muscular; 2. anastomotic.

D. **Cranial portion.**—1. Posterior meningeal; 2. posterior spinal; 3. anterior spinal; 4. posterior cerebellar.

BRANCHES OF THE SECOND OR VERTEBRAL PORTION

1. The **lateral spinal branches** run through the intervertebral foramina into the vertebral canal, and there divide into two branches: (*a*) The spinal, which ramifies on the backs of the bodies of the cervical vertebræ; and (*b*) the medullary, which runs along the spinal nerves, supplies the cord and its membranes, and anastomoses with the arteries above and below. 2. The **muscular branches** supply the deep muscles of the neck, and anastomose with the ascending cervical, occipital, and deep cervical arteries.

BRANCHES OF THE THIRD OR OCCIPITAL PORTION

1. **Muscular,** to the muscles forming the suboccipital triangle; 2. **anastomotic,** to the branches of the occipital artery.

BRANCHES OF THE FOURTH OR CRANIAL PORTION

1. The **posterior meningeal** is a small branch given off as the vertebral artery pierces the dura mater to enter the cranium. It supplies the bone and dura mater of the posterior fossa of the skull, and anastomoses with the posterior meningeal branches derived from the occipital and ascending pharyngeal arteries. It gives branches to the falx cerebelli (fig. 387).

2. The **posterior spinal artery** runs downwards obliquely along the side of the medulla to the back of the cord, down which it passes behind the roots of the spinal nerves, being reinforced by lateral branches running inwards along these nerves, in the neck from the vertebral, in the dorsal region from the intercostals, and in the lumbar region from the lumbar arteries. It can be traced as low as the end of the spinal cord.

3. The **anterior spinal artery** comes off from the vertebral a little below its termination in the basilar artery. Descending obliquely inwards in front of the medulla, it unites on a level with the foramen magnum with its fellow of the opposite side. The single vessel thus formed runs downwards in front of the spinal cord beneath the pia mater as far as the termination of the cord, being reinforced by the lateral spinal branches the whole way down (fig. 387). The spinal arteries are described in detail with the anatomy of the spinal cord.

4. The **posterior inferior cerebellar** (fig. 340)—the largest branch of the vertebral—arises from that vessel just before it joins its fellow to form the basilar artery. At times it may come off from the basilar itself. It runs, at first outwards across the restiform body between the origin of the pneumogastric and hypoglossal nerves, and, descending towards the vallecula, there divides into two branches, an internal and external. (*a*) The **internal** or **inferior vermiform branch** runs backwards between the vermiform process and the lateral hemisphere of the cerebellum. It supplies the vermiform process, and anastomoses with the artery of the opposite side, and with the superior vermiform branch of the superior cerebellar. (*b*) The **external** or **hemispheral branch** runs outwards, and, ramifying over the under surface of the cerebellar hemisphere, supplies its cortex and anastomoses along its outer margin with the superior cerebellar arteries.

From the undivided trunk of the posterior inferior cerebellar artery branches are given to the choroidal plexus and the fourth ventricle.

THE BASILAR ARTERY

The **basilar artery** is formed by the confluence of the right and left vertebral arteries, which meet at an acute angle at the lower border of the pons Varolii. It runs forwards and upwards in a slight groove in the middle line of the pons, and divides at the upper border of that structure at the level of the pretentorial opening into the two posterior cerebral arteries.

BRANCHES OF THE BASILAR ARTERY

The **branches of the basilar artery** are:—1. Transverse or pontal; 2. internal auditory; 3. anterior cerebellar; 4. superior cerebellar; 5. posterior cerebral.

1. The **transverse** or **pontal arteries** are numerous small vessels which come off at right angles on either side of the basilar artery, and, passing outwards over the pons, supply that structure and adjacent parts of the brain.

2. The **internal auditory artery,** a long slender vessel, accompanies the auditory nerve into the internal auditory meatus (fig. 387). It here lies between the facial and auditory nerves, and at the bottom of the meatus passes into the internal ear, and anastomoses with the other auditory arteries. (See INTERNAL EAR.)

3. The **anterior cerebellar**—or anterior inferior cerebellar artery, as it is sometimes called—arises from the basilar soon after its origin, passes outwards and backwards across the pons, and then over the crus cerebelli to the front part of the under surface of the cerebellum. It anastomoses with the posterior inferior cerebellar artery (fig. 340).

4. The **superior cerebellar** comes off from the basilar immediately behind its bifurcation into the posterior cerebral arteries. It courses outwards and backwards over the pons, in a curve roughly corresponding to that of the posterior cerebral artery, from which it is separated by the third cranial nerve; but, soon sinking into the groove between the pons and the crus cerebri, it curves round the latter structure on to the upper surface of the cerebellum, lying nearly parallel to the fourth nerve. Here it divides into two branches, an internal and external. (*a*) The **internal** or **superior vermiform branch** courses backwards along the superior vermiform process, anastomosing with its fellow of the opposite side, and at the posterior notch of the cerebellum with the inferior vermiform branch of the posterior inferior cerebellar artery. (*b*) The **external** or **hemispheral branch** runs outwards to the circumference of the cerebellum, anastomosing with the external branch of the inferior posterior cerebellar artery.

Branches are given off from the main trunk of the superior cerebellar artery, or from its internal branch to the valve of Vieussens, the optic lobes, the pineal gland, and the choroid plexus.

5. The **posterior cerebral arteries** are the two terminal branches into which the basilar bifurcates at the upper border of the pons immediately behind the posterior perforated space. Each artery runs at first outwards and a little forwards across the crus cerebri immediately in front of the third nerve, which separates it from the superior cerebellar artery. After receiving the posterior communicating artery, which runs backwards from the internal carotid, the posterior cerebral turns backwards on to the under surface of the cerebral hemisphere, where it breaks up into branches for the supply of the temporo-sphenoidal and occipital lobes.

The **branches of the posterior cerebral artery** may be divided into the ganglionic or central, and the cortical or hemispheral.

(*a*) The **ganglionic** or **central branches**, are divided into the postero-median; the posterior choroid; and the postero-lateral. (i) The **postero-median branches** come off from the posterior cerebral near its origin, and, passing through the cerebral substance forming the posterior perforated spot, supply the inner part of the optic thalamus and the walls of the third ventricle; (ii) the **posterior choroid branch** passes through the transverse fissure to the velum interpositum and choroid plexus; (iii) the **postero-lateral branches** arise external to the spot where the posterior cerebral artery is joined by the posterior communicating. They run to the posterior part of the optic thalamus and give branches to the crus cerebri and optic lobes or corpora quadrigemina.

(*b*) The **cortical** or **hemispheral branches** are distributed as follows:—(i) the **uncinate**, a branch to the anterior part of the uncinate convolution; (ii) the **temporal**, a branch to the inferior part of the temporal lobe; and (iii) the **temporo-occipital**, a branch to the cuneus, lingual convolution, and outer surface of the occipital lobe.

Here it may be stated, not only in reference to the branches of the posterior cerebral artery, but also with respect to the branches of the anterior and middle cerebral arteries, which are described with the internal carotid (page 503), that there is no anastomosis between the cortical and central branches. The cortical and the central form two distinct and separate systems. The cortical may or may not anastomose with each other, but the communication between the neighbouring cortical branches is seldom sufficient to maintain the nutrition of an area when the vessel that normally supplies it is obstructed. The central branches are so-called end-vessels and do not anastomose with each other. Hence obstruction of the middle cerebral or Sylvian artery leads to softening of the area supplied by its central branches, but not always to softening of the region supplied by its cortical branches. Indeed the cortical region may escape completely, although the central area is irreparably disorganised. The gross anastomosis of the posterior cerebral with the anterior and middle cerebral arteries through the circle of Willis is described with the branches of the internal carotid (page 504).

SUMMARY OF THE DISTRIBUTION OF THE CEREBRAL ARTERIES

Here it may be of advantage to give a brief summary of the distribution of the anterior, middle, and posterior cerebral arteries, the branches of which have already been described in detail. The branches of each are divided into the central or ganglionic, and the cortical or hemispheral. The central branches arise at the commencement of the cerebral arteries about the circle of Willis, whilst the cortical are derived chiefly from the termination of these vessels.

(A) The **central branches** are divided into six sets—two median and four lateral. 1. The **two median** are—(1) The **antero-median**, which arise from the anterior cerebral and the anterior communicating, and supply the fore end of the caudate nucleus, and (2) the **postero-median**, which arise from the posterior cerebral, and supply the inner part of the optic thalamus and neighbouring wall of the third ventricle. 2. The **four lateral**, two on each side, are also divided into antero-lateral, and postero-lateral. (1) The **antero-lateral** arise from the middle cerebral, and, passing through the anterior perforated spot, supply the lenticular nucleus, the posterior part of the caudate nucleus, the internal and external capsules, and the outer part of the optic thalamus. (2) The **postero-lateral** arise from the posterior cerebral, and supply the hinder part of the optic thalamus, the crus, and the optic lobes or corpora quadrigemina.

(B) The **cortical branches** ramify in the pia mater, giving off branches to the cortical substance, some of which extend through it to the underlying white substance. The cortical branches of the **anterior cerebral**, roughly speaking, supply the median surface of the frontal lobe as far as the precuneus, the inner part of its orbital surface, and part of its convex surface, viz. the highest part of the ascending frontal and the first and most of the second frontal convolutions. The cortical branches of the **middle cerebral**—or Sylvian artery as it is often called, because of its relation to the Sylvian fissure—supply the most important area, namely, the motor convolutions; and also the largest, namely, the inferior frontal, the ascending parietal, part of the inferior parietal, the supramarginal and angular, the posterior part of the superior parietal, the first temporal, and the anterior part of the second and third temporal convolutions. The cortical branches of the **posterior cerebral** supply the occipital lobe, and the inferior aspect of the temporal lobe.

It will be seen, therefore, that the middle cerebral supplies the motor region, both central and cortical, except a part of the leg centre. It also supplies the region of the cortex that subserves cutaneous sensibility, the cortical auditory centre, and in part the higher visual centre. It likewise supplies all the cortical regions concerned in speech processes in the left hemisphere. The anterior cerebral supplies only a small part of the motor region—namely, the part of the leg centre that occupies the paracentral lobule and the highest part of the ascending frontal convolution. The posterior cerebral supplies the visual path from the middle of the tract backwards, and the half vision centre in the occipital lobe. It supplies also the corpora quadrigemina and the sensory part of the internal capsule.

THE THYROID AXIS

The **thyroid axis** arises from the upper and front part of the subclavian artery, usually opposite the internal mammary, and a little internal to the inner border of the scalenus anticus. It is a short thick trunk, and divides almost immediately into three radiating branches—namely, the **inferior thyroid**, the **suprascapular**, and the **transverse cervical** (fig. 330).

Occasionally the posterior scapular branch of the transverse cervical arises from the third portion of the subclavian; the superficial cervical, the other branch into which the transverse cervical divides, then commonly comes off from the axis.

THE INFERIOR THYROID ARTERY

The **inferior thyroid**, the largest of the three branches into which the thyroid axis divides, ascends tortuously upwards and inwards in front of the vertebral artery, the recurrent laryngeal nerve, and the longus colli muscle, and behind the common carotid, and the sympathetic nerve or its middle cervical ganglion, to the thyroid body, where it anastomoses with the superior thyroid artery and the artery of the opposite side. It gives off the following branches:—(1) Muscular; (2) ascending cervical; (3) œsophageal; (4) tracheal; and (5) inferior laryngeal.

(1) The **muscular branches** supply the scalenus anticus, longus colli, sterno-hyoid, sterno-thyroid, and omo-hyoid muscles, and the inferior constrictor muscle of the pharynx.

(2) The **ascending cervical** (fig. 329) is given off from the inferior thyroid as that vessel is passing beneath the carotid sheath. It ascends between the scalenus anticus and the rectus capitis anticus major, lying parallel and a little internal to the phrenic nerve and behind the internal jugular vein. It anastomoses with the vertebral, ascending pharyngeal, and occipital arteries, and supplies the following branches:—(*a*) **Muscular,** to the deep muscles of the neck; (*b*) **spinal,** which enter the spinal canal with spinal branches of the vertebral artery; and (*c*) **phrenic,** to the phrenic nerve. Two veins accompany the ascending cervical artery, and end in the innominate vein.

(3) The **œsophageal branches** of the inferior thyroid artery supply the œsophagus, and anastomose with the other arteries supplying that tube.

(4) The **tracheal branches** ramify on the trachea, where they anastomose with the tracheal branches of the superior thyroid and bronchial arteries.

(5) The **inferior laryngeal branch** passes along the trachea to the back of the cricoid cartilage in company with the recurrent laryngeal nerve. It enters the larynx beneath the inferior constrictor. Its further distribution in that organ is described under Larynx.

THE SUPRASCAPULAR ARTERY

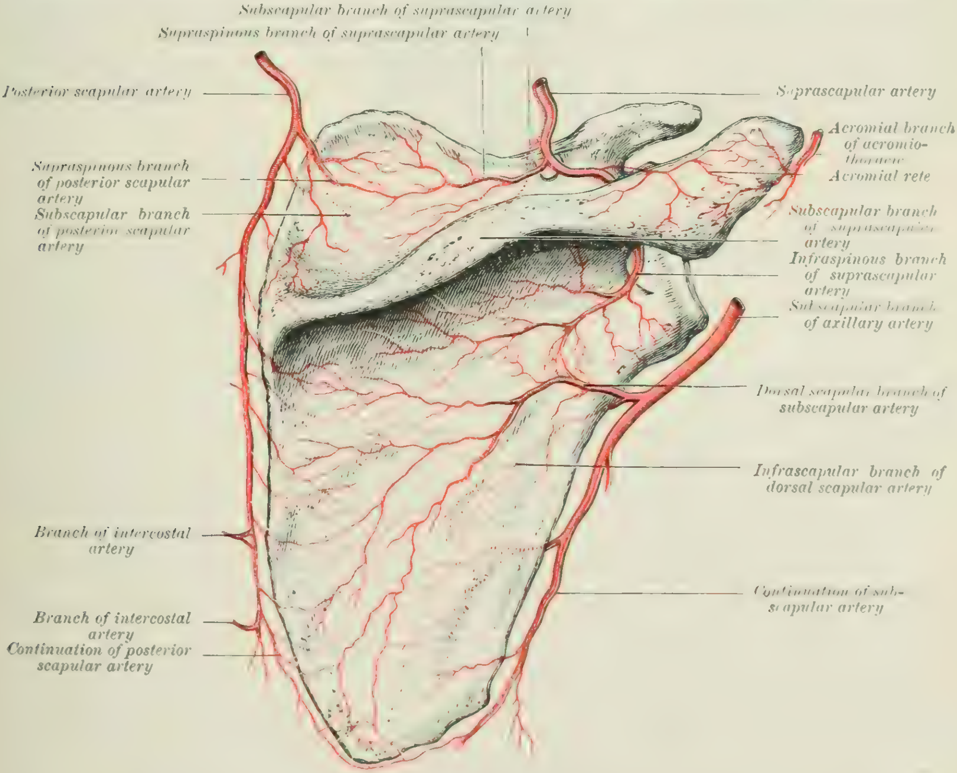
The **suprascapular,** or **transversalis humeri,** passes more or less transversely outwards across the root of the neck, lying first beneath the sterno-mastoid, and then in the subclavian triangle behind the clavicle and subclavius muscle. At the external angle of this space it is joined by the suprascapular nerve, sinks beneath the posterior belly of the omo-hyoid, and passes over the ligament bridging the scapular notch, the nerve passing through the notch (fig. 343). It then ramifies in the supraspinous fossa of the scapula, and, winding downwards round the base of the spine over the neck of the scapula, enters the infraspinous fossa, and terminates by anastomosing with the dorsal scapular and posterior scapular arteries. As it lies under cover of the sterno-mastoid muscle, it crosses the phrenic nerve and the scalenus anticus; and as it courses through the subclavian triangle, it is separated by the cervical fascia which descends from the omo-hyoid to the first rib, from the subclavian artery and brachial plexus of nerves. If this artery is seen in tying the subclavian it should not be injured, as it is one of the chief vessels by which the collateral circulation is carried on after ligature of the subclavian in the third part of its course. At the outer part of the subclavian triangle it is covered by the trapezius, and after passing over the scapular ligament it pierces the supraspinous fascia and passes beneath the supra-spinatus muscle, and ramifies between it and the bone. In the infraspinous fossa it lies between the infra-spinatus and the bone. The artery is accompanied by two veins.

The **branches of the suprascapular** are:—(1) The inferior sterno-mastoid, given off to that muscle as the vessel crosses behind it; (2) the subclavicular to the subclavius muscle; (3) the nutrient, to the clavicle; (4) the suprasternal, which passes over the sternal end of the clavicle to the skin of the upper part of the chest; (5) the acromial, to the arterial rete or plexus on the acromial process, to reach which it pierces the trapezius; (6) the articular, to the acromio-clavicular joint and shoulder-joint; (7) the subscapular, given off as the artery is passing over the suprascapular ligament, descends to the subscapular fossa between the subscapularis and the bone, and anastomoses with the infrascapular branch of the dorsal scapular artery, and with the subscapular and posterior scapular arteries; (8) the supraspinous branches, which ramify in the supraspinous fossa, and supply the supra-spinatus muscle and the periosteum and the nutrient artery to the bone; (9) the infraspinous branches, which ramify in a similar way in the infraspinous fossa, giving off like twigs to the infra-spinatus muscle, the periosteum, and the bone.

THE TRANSVERSE CERVICAL ARTERY

The **transverse cervical** or **transversalis colli artery**—somewhat larger than the suprascapular artery—runs like the latter vessel transversely outwards across the root of the neck, but on a slightly higher plane, and a little above the clavicle.

FIG. 343.—SCHEME OF ANASTOMOSES OF THE RIGHT SCAPULAR ARTERIES. (Walsham.)


Subscapular branch of suprascapular artery
Supraspinous branch of suprascapular artery
Posterior scapular artery
Suprascapular artery
Acromial branch of acromio-thoracic
Acromial rete
Supraspinous branch of posterior scapular artery
Subscapular branch of posterior scapular artery
Subscapular branch of suprascapular artery
Infraspinous branch of suprascapular artery
Subscapular branch of axillary artery
Dorsal scapular branch of subscapular artery
Infrascapular branch of dorsal scapular artery
Branch of intercostal artery
Continuation of subscapular artery
Branch of intercostal artery
Continuation of posterior scapular artery

At its origin from the thyroid axis it lies under the sterno-mastoid; on leaving the cover of this muscle, it crosses the upper part of the subclavian triangle, lying here only beneath the platysma and cervical fascia; further outwards, it passes beneath the anterior margin of the trapezius and omo-hyoid muscle, and at the outer margin of the levator anguli scapulæ divides into the posterior scapular and superficial cervical arteries. In this course it crosses the phrenic nerve, the scalenus anticus, the brachial plexus, and the scalenus medius. At times it passes between the cords of the brachial plexus.

The **terminal branches of the transverse cervical artery** are:—(1) The posterior scapular; and (2) the superficial cervical. The posterior scapular occasionally arises from the third portion of the subclavian artery.

(1) The **posterior scapular**—the apparent continuation of the transverse cervical artery—begins at the outer border of the levator anguli scapulæ, and, continuing its course beneath this muscle to the upper and posterior angle of the scapula, turns downwards and skirts along the posterior border of the scapula, between the serratus magnus in front and the levator anguli scapulæ and rhomboideus minor and major behind, to the inferior angle, where it anastomoses with the subscapular artery. It gives off the following branches:—(*a*) **Supraspinous,** which ramifies between the supraspinous muscle and the trapezius, and sends branches through the muscle into the fossa, to anastomose with the suprascapular artery. (*b*) **Infraspinous branches,** one or more of which enter the infraspinous fossa, and anastomose with the dorsal scapular. (*c*) **Subscapular branches,** which enter the subscapular fossa, and anastomose with the suprascapular, infrascapular, and subscapular arteries. (*d*) **Muscular branches,** to the muscles between which it runs and to the latissimus dorsi. These branches anastomose with the posterior divisions of the intercostal arteries.

(2) The **superficial cervical artery,** smaller than the posterior scapular, ascends under cover of the anterior margin of the trapezius, lying upon the levator anguli scapulæ and splenius muscles. It supplies branches to the trapezius, levator anguli scapulæ, and splenius muscles, and the posterior chain of lymphatic glands. It anastomoses with the superficial branch of the princeps cervicis which descends from the occipital between the splenius and complexus. It is accompanied by two veins. This artery may arise directly from the thyroid axis, or from the third part of the subclavian artery.

THE INTERNAL MAMMARY ARTERY

The **internal mammary artery** (fig. 344) comes off from the lower part of the first portion of the subclavian, usually opposite the thyroid axis, close to the inner edge of the scalenus anticus, occasionally opposite the vertebral, or at a spot between these two vessels. It descends with a slight inclination forwards and inwards, under cover of the clavicle, and enters the thorax behind the cartilage of the first rib, and thence passes down behind the cartilages of the next succeeding ribs, about half an inch from the external margin of the sternum, to the sixth interspace, where it divides into the **superior epigastric** and **musculo-phrenic.** It is accompanied by two veins, which unite into one trunk behind the first intercostal muscle, and pass to the inner side of the artery into the corresponding vena innominata; occasionally on the right side into the vena cava superior direct. The artery may be divided into two portions, the cervical and the thoracic.

The **cervical portion** is covered by the sterno-mastoid muscle, subclavian vein, and internal jugular vein, and is crossed obliquely, from without inwards, by the phrenic nerve. It rests upon the pleura and courses round the upper part of the innominate vein. There is no branch from this part of the artery.

The **thoracic portion** lies behind the cartilages of the six upper ribs, and in the interspace between the ribs has in front of it the pectoralis major and the internal intercostal muscles and the external intercostal membrane. Behind, it is in contact above with the pleura, but it is separated from it lower down by slips of the triangularis sterni. On the left side the artery between the fourth and sixth ribs may be said to be in the anterior mediastinum, the pleura here forming a notch for the heart. In the first, second, and third spaces the artery, if wounded, can be easily tied; but in the fourth space the operation is attended with more difficulty. The remaining spaces are so narrow that a portion of the cartilage would have to be removed to expose the vessel.

The **branches of the internal mammary artery** are:—(1) The superior phrenic; (2) the mediastinal, or thymic; (3) the pericardiac; (4) the sternal; (5) the anterior intercostals; (6) the perforating; (7) the lateral infracostal; (8) the superior epigastric; and (9) the musculo-phrenic.

(1) The **superior phrenic,** or **comes nervi phrenici,** is a long slender vessel which comes off from the internal mammary just after it has entered the chest, and descends with the phrenic nerve, at first between the pleura and innominate vein;

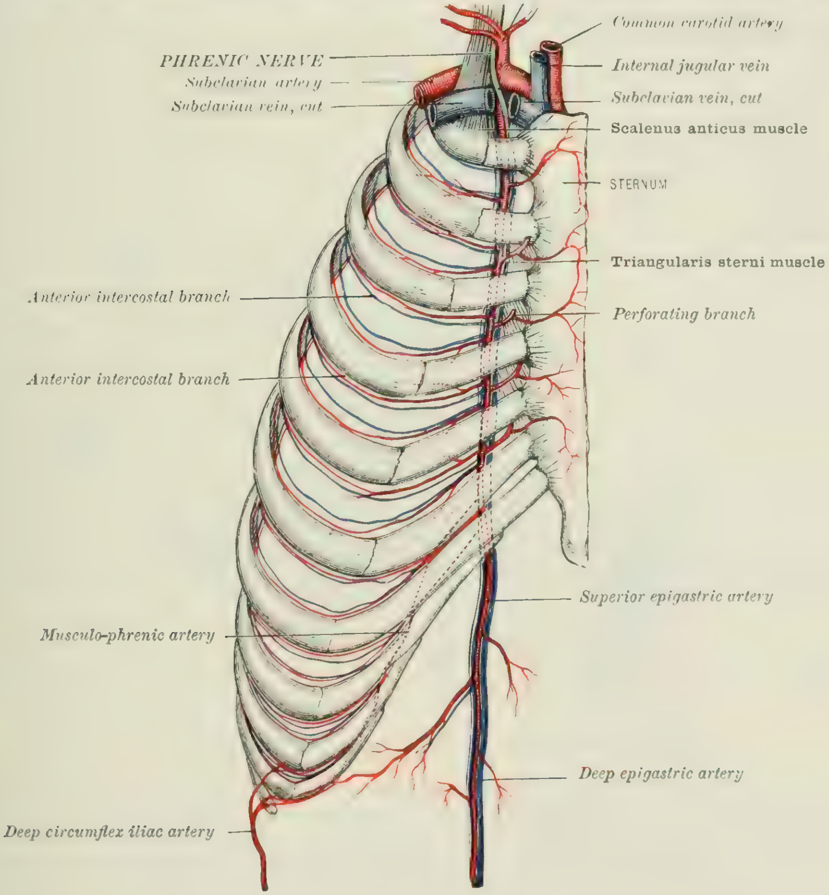
then between the pleura and the vena cava superior; and lastly, between the pleura and the pericardium to the diaphragm, where it anastomoses with the other diaphragmatic arteries. It gives branches both to the pleura and pericardium.

(2) The **mediastinal** or **thymic branches** come off irregularly from the internal mammary. They are of small size, and supply the connective tissue, fat, and lymphatics in the superior and anterior mediastina and the remains of the thymus gland.

(3) The **pericardiac branches** are distributed to the anterior surface of the pericardium.

(4) The **sternal branches** enter the nutrient foramina in the sternum, and also supply the triangularis sterni.

Fig. 344.—Scheme of the Right Internal Mammary Artery. (Walsham.)


Common carotid artery
PHRENIC NERVE
Internal jugular vein
Subclavian artery
Subclavian vein, cut
Subclavian vein, cut
Scalenus anticus muscle
STERNUM
Triangularis sterni muscle
Anterior intercostal branch
Perforating branch
Anterior intercostal branch
Superior epigastric artery
Musculo-phrenic artery
Deep epigastric artery
Deep circumflex iliac artery

(5) The **anterior intercostal arteries** (fig. 344)—two in each of the five or six upper intercostal spaces—run outwards from the internal mammary artery, along the lower border of the rib above and the upper border of the rib below, and anastomose with the corresponding upper and lower branches of the aortic intercostals. Each pair of branches sometimes arises by a common trunk from the internal mammary, which in this case soon divides into an upper and a lower branch, as above described. They lie at first between the internal intercostal muscles and the pleura; afterwards between the external and internal intercostal muscles. They supply the contiguous muscles, the pectoralis major, and the ribs.

(6) The **perforating** or **anterior perforating branches**—five or six in number, one corresponding to each of the five or six upper spaces—come off from the front

of the internal mammary, between the superior and inferior anterior intercostals, and, perforating the internal intercostal muscles, pass forwards between the costal cartilages to the pectoralis major, which they supply. The terminal twigs perforate that muscle close to the sternum, and are distributed to the integument. The **second, third,** and **fourth perforating** supply the inner and deep surface of the mammary gland, and become greatly enlarged during lactation. They frequently require ligation in excision of the breast.

(7) The **lateral infracostal artery** (Macalister) is given off close to the first rib, and descends behind the ribs just external to the costal cartilages. It anastomoses with the upper intercostal arteries. This vessel is often of insignificant size, or absent.

(8) The **superior epigastric artery** (fig. 344), or internal terminal branch of the internal mammary artery, leaves the thorax behind the seventh costal cartilage by passing through the costo-xiphoid space in the diaphragm. It is the direct prolongation of the internal mammary downwards. In the abdomen it descends behind the rectus muscle, between its posterior surface and its sheath, and, lower, entering the substance of the muscle, anastomoses with the deep epigastric, a branch of the external iliac. It gives off the following small branches:—(*a*) The **phrenic,** to the diaphragm; (*b*) the **xiphoid,** which crosses in front of the ensiform cartilage, and anastomoses with the artery of the opposite side; (*c*) the **cutaneous,** which perforate the anterior layer of the sheath of the rectus and supply the integuments; (*d*) the **muscular,** to the rectus muscle, some of which perforate the rectus sheath laterally, and are distributed to the oblique muscles; (*e*) the **hepatic** (on the right side only), which pass along the falciform ligament to the liver, and anastomose with the hepatic artery; (*f*) the **peritoneal** which perforate the posterior layer of the sheath of the rectus, and ramify on the peritoneum.

(9) The **musculo-phrenic,** or external terminal branch of the internal mammary artery, skirts outwards and downwards behind the costal cartilages of the false ribs along the costal attachments of the diaphragm, which it perforates opposite the ninth rib. It terminates, much reduced in size, at the tenth or eleventh intercostal space by anastomosing with the ascending branch of the deep circumflex iliac artery. It gives off in its course the following small branches:—(*a*) The **phrenic** for the supply of the diaphragm; (*b*) the **anterior intercostals,** two in number for each of the lower five or six intercostal spaces, are distributed like those to the upper spaces, already described, and anastomose like them with the corresponding branches of the lower aortic intercostals; (*c*) the **muscular** for the supply of the oblique muscles of the abdomen.

Branches of the Second Part of the Subclavian Artery

THE SUPERIOR INTERCOSTAL ARTERY

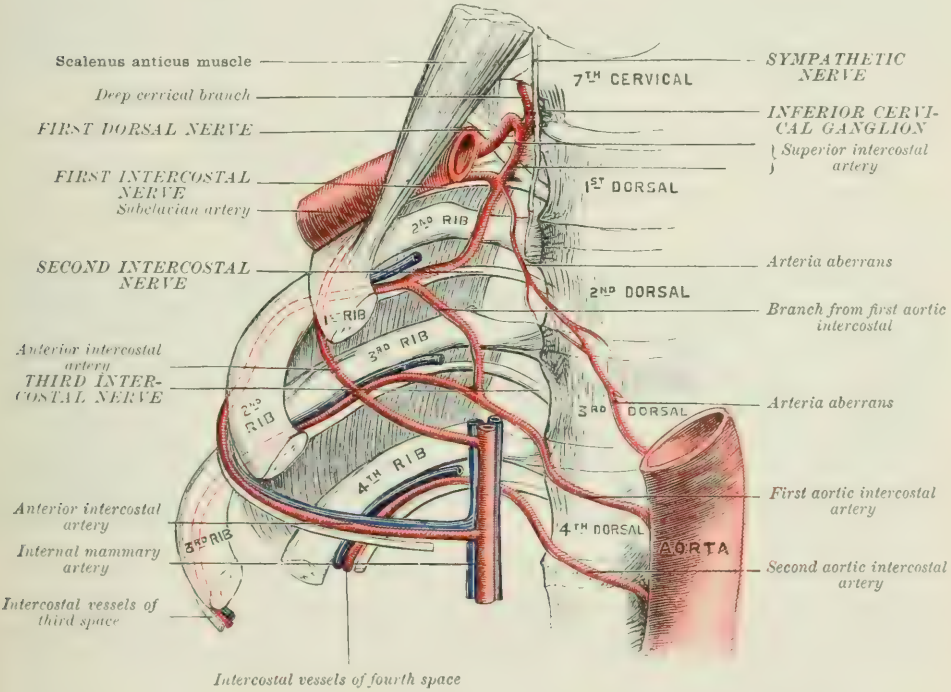
1. The **superior intercostal artery** (fig. 345) usually arises from the back part of the second portion of the subclavian artery, behind the scalenus anticus on the right side, but sometimes just internal to that muscle on the left side. It at first runs backwards and a little upwards above the apex of the pleura, and then turns downwards and enters the thorax in front of the neck of the first rib. It terminates in a branch which runs forwards in the first intercostal space. Frequently, and especially on the right side, it is continued in front of the neck of the second rib, and supplies a branch to the second intercostal space. This branch may then be reinforced by an intercostal from the aorta, which supplies the space when the branch is not present. As the superior intercostal crosses the neck of the first rib, it lies internal to the anterior branch of the first dorsal nerve, and external to the superior thoracic ganglion of the sympathetic. That part of the superior intercostal which intervenes between its origin from the subclavian and its first branch, is sometimes called the **costo-cervical artery.**

Branches.—The superior intercostal gives off:—(1) The deep cervical; (2) the first intercostal; and (3) the arteria aberrans.

(1) The **deep cervical branch** is given off from the superior intercostal just

before the latter enters the thorax. It passes directly backwards, first between the seventh and eighth cervical nerves, and then between the transverse process of the seventh cervical vertebra and the neck of the first rib, having the body of the seventh cervical vertebra to its inner side, and the intertransverse muscle to its outer side. It then turns upwards in the groove between the transverse and spinous processes of the cervical vertebræ lying upon the semispinalis colli. It is covered by the complexus. Between these muscles, near the axis, it anastomoses with the deep branch of the princeps cervicis of the occipital artery. The deep cervical is homologous in its course to the posterior branch of an aortic intercostal, being morphologically the posterior branch of the intercostal artery for the seventh cervical space. It gives off the following small branches:—(*a*) **Muscular**, to the semispinalis colli and complexus; (*b*) **anastomotic**, which anastomose with branches of the vertebral, ascending cervical and princeps cervicis arteries; and (*c*) **vertebral** or **spinal**, which enters the spinal canal through the intervertebral foramen with the eighth cervical nerve.

FIG. 345.—SCHEME OF THE RIGHT SUPERIOR INTERCOSTAL ARTERY. (Walsham.)


Scalenus anticus muscle
Deep cervical branch
FIRST DORSAL NERVE
FIRST INTERCOSTAL NERVE
Subclavian artery
SECOND INTERCOSTAL NERVE
Anterior intercostal artery
THIRD INTERCOSTAL NERVE
Anterior intercostal artery
Internal mammary artery
Intercostal vessels of third space
Intercostal vessels of fourth space
SYMPATHETIC NERVE
INFERIOR CERVICAL GANGLION
Superior intercostal artery
Arteria aberrans
Branch from first aortic intercostal
Arteria aberrans
First aortic intercostal artery
Second aortic intercostal artery
7TH CERVICAL
1ST DORSAL
2ND RIB
2ND DORSAL
1ST RIB
3RD RIB
2ND RIB
3RD DORSAL
4TH RIB
4TH DORSAL
AORTA
3RD RIB

(2) The **first intercostal branch** runs forwards in the first intercostal space, and, like the second intercostal branch, which, when present, runs to the second space on the right side, resembles in its course and distribution the succeeding intercostals derived from the aorta. (See BRANCHES OF THORACIC AORTA.)

(3) The **arteria aberrans**, when present, comes off from the inner side of the right superior intercostal, and occasionally from the right subclavian itself. (See page 506.) It descends as a delicate vessel into the thorax, passing backwards and inwards behind the œsophagus as far as the third or fourth thoracic vertebra, where in some cases it is found to anastomose with a similar delicate branch coming off from the aorta below the ductus arteriosus. This anastomosis, which represents the remains of the right dorsal aortic stem, may become enlarged, and the subclavian artery on the right side be derived from the arch of the aorta. This accounts for the subclavian in such circumstances passing behind the œsophagus. (See VARIATIONS OF THE ARCH OF THE AORTA.)

THE AXILLARY ARTERY

The term axillary is applied to that portion of the main arterial stem of the upper limb that passes through the axilla. The axillary artery therefore is continuous with the subclavian above and with the brachial below. It extends from the outer border of the first rib to the lower edge of the teres major muscle, and has the shoulder-joint and the neck of the humerus to its outer side. When the arm is placed close to the side of the body, the artery forms a gentle curve with its convexity upwards; but when the arm is carried out from the side at right angles to the trunk in the ordinary dissecting position, the vessel takes a nearly straight course, which will then be indicated by a line drawn from the middle of the clavicle to a spot midway between the condyles of the humerus. The axillary artery is at first deeply placed beneath the pectoral muscles, but in its lower third is superficial, being covered only by the skin and the superficial fascia and deep fascia. It is divided into three parts—first, second, and third, according as it lies respectively above, beneath, or below the pectoralis minor.

THE FIRST PART OF THE AXILLARY ARTERY

The **first part of the axillary artery** extends from the outer border of the first rib to the upper border of the pectoralis minor. It measures about an inch in length (2·5 cm.).

Relations.—In front it is covered by the skin, superficial fascia, the origin of the platysma, the deep fascia, the pectoralis major, the costo-coracoid membrane, the subclavius muscle and the clavicle when the arm hangs down by the side. The cephalic and acromio-thoracic veins, the external anterior thoracic nerve, and the axillary lymphatic trunk, cross over it. A layer of the deep cervical fascia which has passed under the clavicle also descends in front of it.

Behind, it rests upon the first intercostal space and first intercostal muscle, the first digitation and sometimes a portion of the second digitation of the serratus magnus muscle, and a part of the second rib. The posterior or external respiratory nerve of Bell, on its way to the serratus magnus muscle, passes behind it.

To its **outer side,** and somewhat on a higher plane, are the cords of the brachial plexus.

To its **inner side,** and on a slightly anterior plane, is the axillary vein. The anterior internal thoracic nerve courses between the vein and the artery.

THE SECOND PART OF THE AXILLARY ARTERY

The **second part of the axillary artery** (fig. 346) lies beneath the pectoralis minor deep in the axilla. It measures a little more than an inch in length (3 cm.).

Relations.—In front, in addition to the pectoralis minor, it is covered by the pectoralis major and the integuments.

Behind, it is separated by a considerable interval containing loose connective tissue and fat from the subscapularis muscle; whilst behind, and in contact with it, is the posterior cord of the brachial plexus.

To the **inner side,** but separated from the artery by the inner cord of the brachial plexus, is the axillary vein.

To the **outer side** is the outer cord of the brachial plexus, and at some little distance the coracoid process.

It is thus seen that the second portion of the axillary artery is surrounded on three sides by the cords of the brachial plexus—one behind, one internal, and one external.

THE THIRD PART OF THE AXILLARY ARTERY

The **third part of the axillary artery** (fig. 346) extends from the lower border of the pectoralis minor to the lower border of the teres major. Its upper half lies deeply placed within the axilla, beneath the lower edge of the pectoralis major muscle, but its lower half is in the arm external to the axilla, and is uncovered by muscle. It measures about three inches in length (7·5 cm.).

Relations.—In front it has, in addition to the skin and superficial fascia, the pectoralis major above, and lower down the deep fascia of the arm. It is crossed obliquely by the inner root of the median nerve and by the outer brachial vena comes.

Behind, it lies successively upon the subscapularis, the latissimus dorsi, and teres major muscles. From the first-named muscle it is separated at first by a considerable mass of fat and cellular tissue. The musculo-spiral and circumflex nerves intervene between the artery and the muscles.

On its **outer side** it is separated from the bone by the coraco-brachialis, by which it is partly overlapped, this muscle and the short head of the biceps serving as a guide to the artery in ligature. For a part of its course it has also the musculo-cutaneous nerve and the outer root of the median nerve to its outer side.

To its **inner side** it has the axillary vein, the ulnar nerve, the internal cutaneous nerve, the lesser internal cutaneous nerve, and the inner root of the median nerve. The ulnar nerve is between the artery and the vein. The internal cutaneous nerve is a little in front of the artery as well as internal to it.

Variations in the Axillary Artery

The **chief variations in the axillary artery** are :—(*a*) It may give off the radial artery; (*b*) more rarely, the ulnar artery; (*c*) still more rarely, the interosseous artery, or a **vas aberrans**; (*d*) it may give off a common trunk, from which may arise the subscapular, the anterior and posterior circumflex, and the superior and inferior profunda arteries. The branches of the brachial plexus usually surround this common trunk, and not what is apparently the main brachial artery. The latter vessel indeed would seem in many of these instances to be really an enlarged vas aberrans, and the common trunk the main brachial artery, the lower portion of which has been obliterated, i.e. obliterated from the last branch given off from the common trunk to the spot where it is again joined by the vas aberrans. (*e*) The axillary artery may be covered in the third part of its course by a muscular slip (the **dorsi axillaris**), derived from the upper part of the tendon of the latissimus dorsi, and always present in early fœtal life, though as a rule atrophied later.

BRANCHES OF THE AXILLARY ARTERY

The **first part** gives off:—(1) The superior thoracic: and (2) the acromio-thoracic.

The **second part** gives off:—(1) The long thoracic: and (2) the alar thoracic.

The **third part** gives off:—(1) The subscapular: (2) the anterior circumflex: and (3) the posterior circumflex.

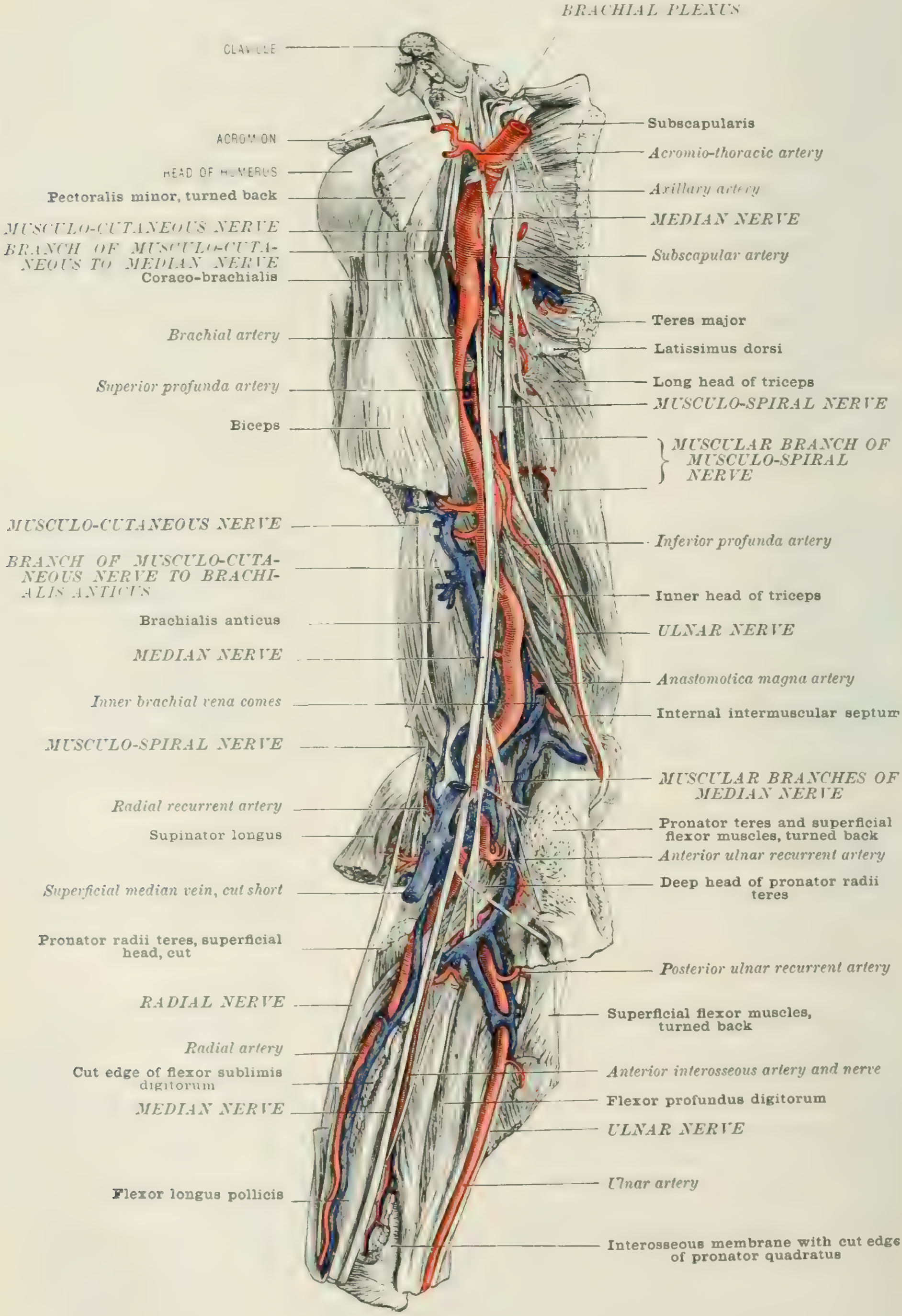
BRANCHES OF THE FIRST PART OF THE AXILLARY ARTERY

1. The **superior** or **short thoracic** is variously given off from the axillary artery, usually either as a common trunk with the next branch, the acromial thoracic, or a little above. It passes behind the axillary vein across the first intercostal space, supplying the intercostal muscles and the upper portion of the serratus magnus, and anastomoses with the intercostal arteries. At times it sends a branch between the pectoralis major and minor, which then, as a rule, more or less takes the place of the pectoral branch of the acromial thoracic.

2. The **acromio-thoracic,** or **thoracic axis,** arises from the front part of the axillary just above the upper border of the pectoralis minor. It is a short trunk, and coming off from the front of the artery pierces the costo-coracoid membrane, and then divides into three or four small branches, named from their direction:—(*a*) the acromial, or thoracica acromialis; (*b*) the humeral, or thoracica humeralis; (*c*) the pectoral, or short thoracic of some authors; and (*d*) the clavicular.

FIG. 346.—THE LOWER PART OF THE AXILLARY, THE BRACHIAL, AND THE RADIAL AND ULNAR ARTERIES, RIGHT SIDE.

(From a dissection in the Museum of the Royal College of Surgeons of England.)


BRACHIAL PLEXUS
CLAVICLE
ACROMION
HEAD OF HUMERUS
Pectoralis minor, turned back
MUSCULO-CUTANEOUS NERVE
BRANCH OF MUSCULO-CUTANEOUS TO MEDIAN NERVE
Coraco-brachialis
Brachial artery
Superior profunda artery
Biceps
MUSCULO-CUTANEOUS NERVE
BRANCH OF MUSCULO-CUTANEOUS NERVE TO BRACHIALIS ANTICUS
Brachialis anticus
MEDIAN NERVE
Inner brachial vena comes
MUSCULO-SPIRAL NERVE
Radial recurrent artery
Supinator longus
Superficial median vein, cut short
Pronator radii teres, superficial head, cut
RADIAL NERVE
Radial artery
Cut edge of flexor sublimis digitorum
MEDIAN NERVE
Flexor longus pollicis
Subscapularis
Acromio-thoracic artery
Axillary artery
MEDIAN NERVE
Subscapular artery
Teres major
Latissimus dorsi
Long head of triceps
MUSCULO-SPIRAL NERVE
MUSCULAR BRANCH OF MUSCULO-SPIRAL NERVE
Inferior profunda artery
Inner head of triceps
ULNAR NERVE
Anastomotica magna artery
Internal intermuscular septum
MUSCULAR BRANCHES OF MEDIAN NERVE
Pronator teres and superficial flexor muscles, turned back
Anterior ulnar recurrent artery
Deep head of pronator radii teres
Posterior ulnar recurrent artery
Superficial flexor muscles, turned back
Anterior interosseous artery and nerve
Flexor profundus digitorum
ULNAR NERVE
Ulnar artery
Interosseous membrane with cut edge of pronator quadratus

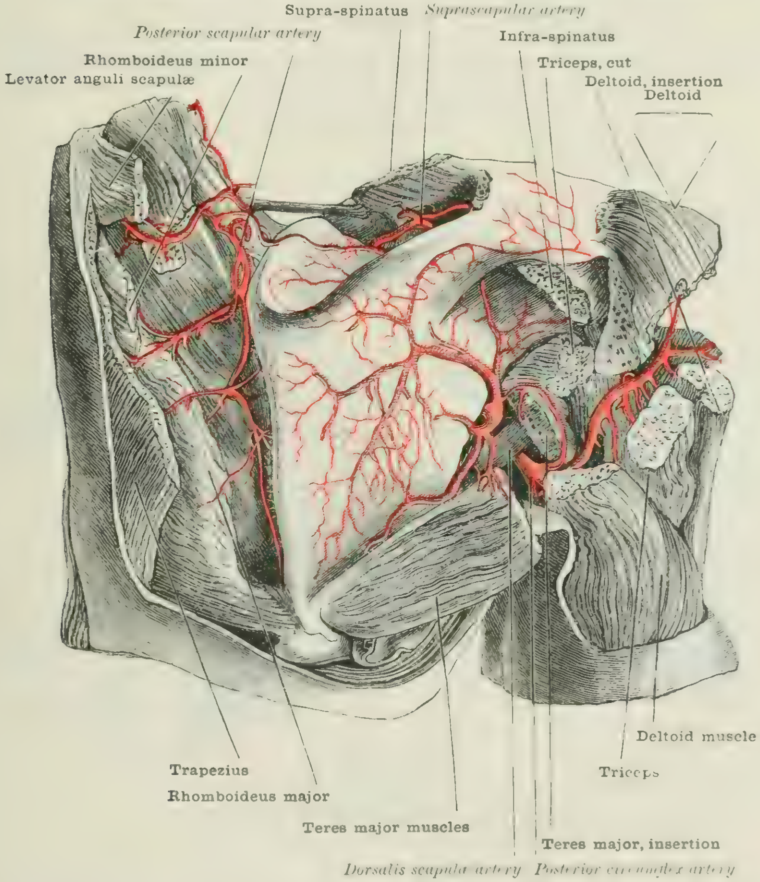
(*a*) The **acromial branch** or branches pass outwards across the coracoid process, frequently through the deltoid muscle, which they in part supply, to the acromion, where they form, by anastomosing with the anterior and posterior circumflex and suprascapular arteries, the so-called acromial rete, or plexus of vessels on the surface of that process.

(*b*) The **humeral branch** — the descending branch of some authors — runs downwards with the cephalic vein in the interval between the pectoralis major and the deltoid, and, supplying lateral offsets to these muscles and the adjacent integuments, anastomoses with the anterior and posterior circumflex arteries.

(*c*) The **pectoral branch** passes between the pectoralis major and minor muscles, both of which it supplies, and the superimposed mammary gland. In the female, one or more of these branches which perforate the pectoralis major are often of large size.

Fig. 347.—The Dorsal Scapular Artery, Right Side.

(From a dissection in the Museum of the Royal College of Surgeons.)


Supra-spinatus
Suprascapular artery
Posterior scapular artery
Infra-spinatus
Rhomboideus minor
Triceps, cut
Levator anguli scapulæ
Deltoid, insertion
Deltoid
Deltoid muscle
Triceps
Trapezius
Rhomboideus major
Teres major muscles
Teres major, insertion
Dorsalis scapulæ artery
Posterior circumflex artery

(*d*) The **clavicular branch** passes upwards beneath the clavicle and supplies the subclavius muscle, and anastomoses with the suprascapular artery.

Branches of the Second Part of the Axillary Artery

1. The **long thoracic artery**—also called the external mammary—descends along the lower border of the pectoralis minor, under cover of the pectoralis major, to the walls of the chest. It supplies both pectoral muscles and the serratus

magnus, sends branches round the lower border of the pectoralis major to the mammary gland, and terminates in the intercostal muscles by anastomosing with the aortic intercostals and the internal mammary. It also furnishes branches to the glands of the axilla. The branches to the mammary gland in the female are often of large size.

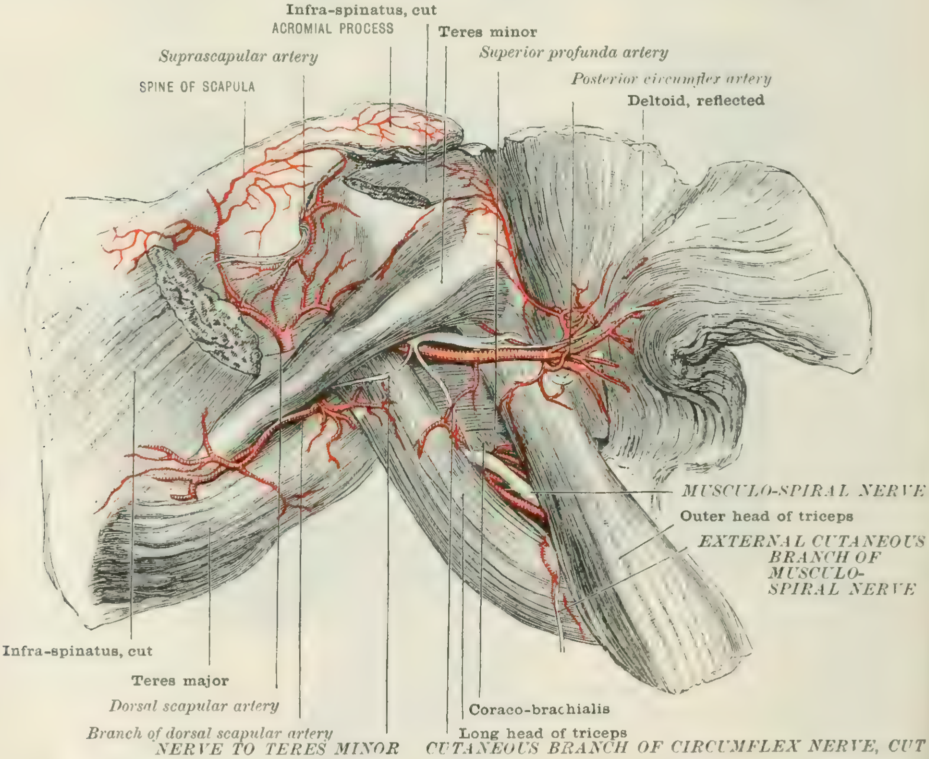
2. The **alar thoracic** are small branches given off either directly from the axillary artery to the lymphatic glands in the axilla, or from some of the other branches of the first or second part of the axillary artery.

Branches of the Third Part of the Axillary Artery

1. The **subscapular artery** is the largest branch of the axillary. It arises opposite the lower border of the subscapularis, and runs downwards and inwards along the anterior border of that muscle under cover of the latissimus dorsi as far as the angle of the scapula, where it anastomoses with the dorsal scapular, posterior scapular, long thoracic, infrascapular, and the intercostal arteries. The long subscapular nerve accompanies it. It supplies the subscapularis, teres major, latissimus dorsi, and serratus magnus muscles, and gives branches to the glands in the axillary space. The course of this large vessel along the posterior border of the axilla should be remembered in opening abscesses in the axilla, and in removing enlarged glands from this space. It is accompanied by two veins, which usually unite and then receive the dorsal scapular vein, and open as a single vein of large size either into the axillary or at the confluence of the inner brachial venæ comites with the basilic vein.

Fig. 348.—The Right Posterior Circumflex Artery.

(From a dissection by Mr. Horner in the Museum of St. Bartholomew's Hospital.)

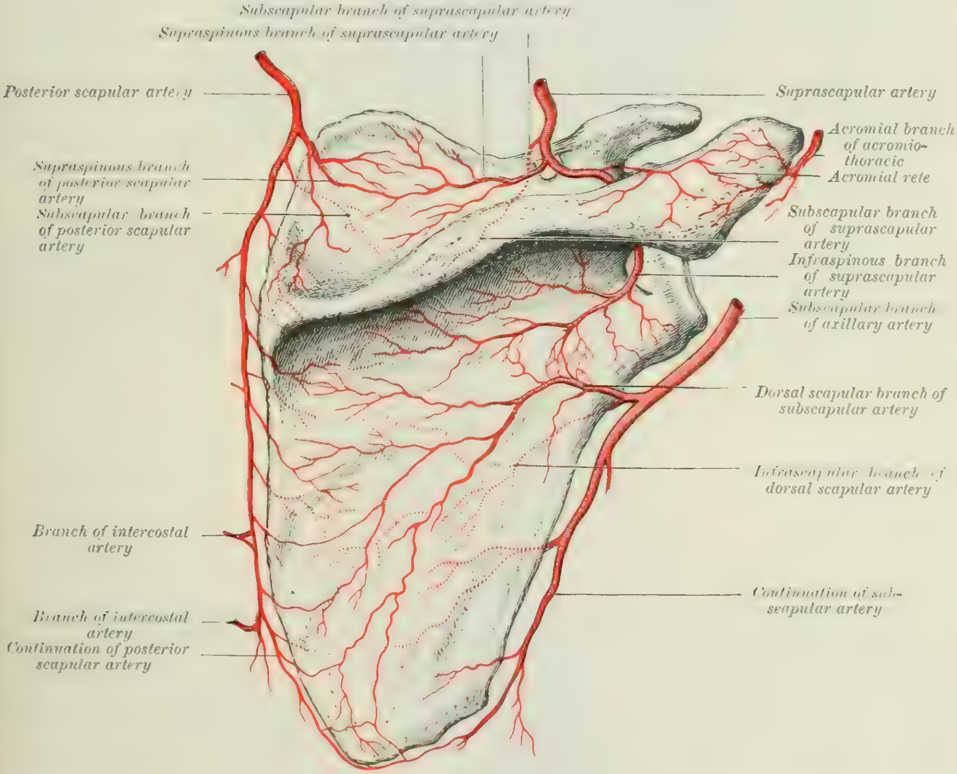

Infra-spinatus, cut
ACROMIAL PROCESS
Teres minor
Suprascapular artery
Superior profunda artery
SPINE OF SCAPULA
Posterior circumflex artery
Deltoid, reflected
MUSCULO-SPIRAL NERVE
Outer head of triceps
EXTERNAL CUTANEOUS BRANCH OF MUSCULO-SPIRAL NERVE
Infra-spinatus, cut
Teres major
Dorsal scapular artery
Coraco-brachialis
Long head of triceps
Branch of dorsal scapular artery
NERVE TO TERES MINOR
CUTANEOUS BRANCH OF CIRCUMFLEX NERVE, CUT

About an inch to an inch and a half from its origin, the subscapular artery gives off the following large branch:—

The **dorsal scapular**, arising from the subscapular, usually at the above-mentioned spot, passes backwards through the triangular space bounded by the subscapularis above, the teres major below, and the long head of the triceps externally, and then between the teres minor and the axillary border of the scapula, which it commonly grooves. It thus reaches the infraspinous fossa, where, under cover of the infraspinatus, it anastomoses with the suprascapular and posterior scapular arteries (fig. 347). As it passes through the triangular space, it gives off a ventral branch, sometimes called the **infrascapular**, which ramifies between the subscapularis and the bone, supplying branches to the subscapularis, to the scapula, and to the shoulder-joint. A second branch is often given off near the triangular space and passes downwards between the teres major and teres minor, supplying both muscles (fig. 348).

The **chief variations in the subscapular artery** are:—(*a*) It may come off with the posterior circumflex; (*b*) it may arise from a trunk common to several other of the branches of the third part of the axillary artery and upper part of the brachial artery; and (*c*) its dorsal scapular branch may arise from the axillary direct.

FIG. 349.—THE ANASTOMOSES ABOUT THE SCAPULA.


Subscapular branch of suprascapular artery
Supraspinous branch of suprascapular artery
Posterior scapular artery
Suprascapular artery
Acromial branch of acromio-thoracic
Acromial rete
Supraspinous branch of posterior scapular artery
Subscapular branch of posterior scapular artery
Subscapular branch of suprascapular artery
Infraspinous branch of suprascapular artery
Subscapular branch of axillary artery
Dorsal scapular branch of subscapular artery
Infrascapular branch of dorsal scapular artery
Branch of intercostal artery
Continuation of subscapular artery
Branch of intercostal artery
Continuation of posterior scapular artery

2. The **anterior circumflex**, usually quite a small vessel, comes off from the outer side of the axillary artery, generally opposite the posterior circumflex. It passes beneath the coraco-brachialis and short and long heads of the biceps, winding transversely round the front of the surgical neck of the humerus, across the bicipital groove, and anastomoses with the posterior circumflex and acromial thoracic arteries. It gives off the following small branches: (*a*) the **bicipital** or ascending, which runs up the bicipital groove to supply the long tendon of the biceps and the shoulder-joint; and (*b*) a **pectoral** or descending branch, which runs downwards along the insertion of the pectoralis major, and supplies the tendon of that muscle. The anterior circumflex artery, in consequence of its being close

to the bone, is sometimes difficult to secure in the operation for excision of the shoulder-joint.

Chief variations.—(*a*) The anterior circumflex may be given off from the posterior circumflex; or (*b*) from a stem common to it and several other vessels. (See VARIATIONS IN THE AXILLARY ARTERY, page 521.)

3. The **posterior circumflex artery** (fig. 348) arises from the hinder part of the axillary, just below the lower border of the subscapularis muscle. It passes through the quadrilateral space, bounded by the teres minor above, the latissimus dorsi and teres major below, the humerus externally, and the long head of the triceps internally, and, winding round the back of the humerus beneath the deltoid, breaks up under cover of that muscle into a leash of branches, which for the most part enter its substance. The circumflex nerve and two venæ comites run with it. It anastomoses with the anterior circumflex, the arteries on the acromion, and the superior profunda artery.

In addition to the leash of vessels to the deltoid, it gives off the following small branches:—(*a*) **nutrient,** to the greater tuberosity of the humerus; (*b*) **articular,** to the back of the shoulder-joint; (*c*) **acromial,** to the plexus on the acromion; and (*d*) **muscular,** to the teres minor and long and short heads of the triceps. One or more of these branches to the triceps (the **tricipital**) descend either between the outer and long head, or in the substance of that muscle to anastomose with an ascending branch from the superior profunda artery. It is by means of this anastomosis that the collateral circulation is chiefly carried on when the axillary or the brachial artery is tied between the origins of the posterior circumflex and superior profunda arteries (fig 330).

The **chief variations in the posterior circumflex** are:—(*a*) It may arise with the subscapular artery as a common trunk. (*b*) It may come off from the brachial, and run up behind the teres major to the quadrilateral space. (*c*) It may give off the inferior profunda, the anterior circumflex, or the dorsal scapular. (*d*) It may be double. (*e*) It may form one of the vessels arising from a trunk common to several branches of the axillary and brachial arteries. (See VARIATIONS IN THE AXILLARY ARTERY, page 521.

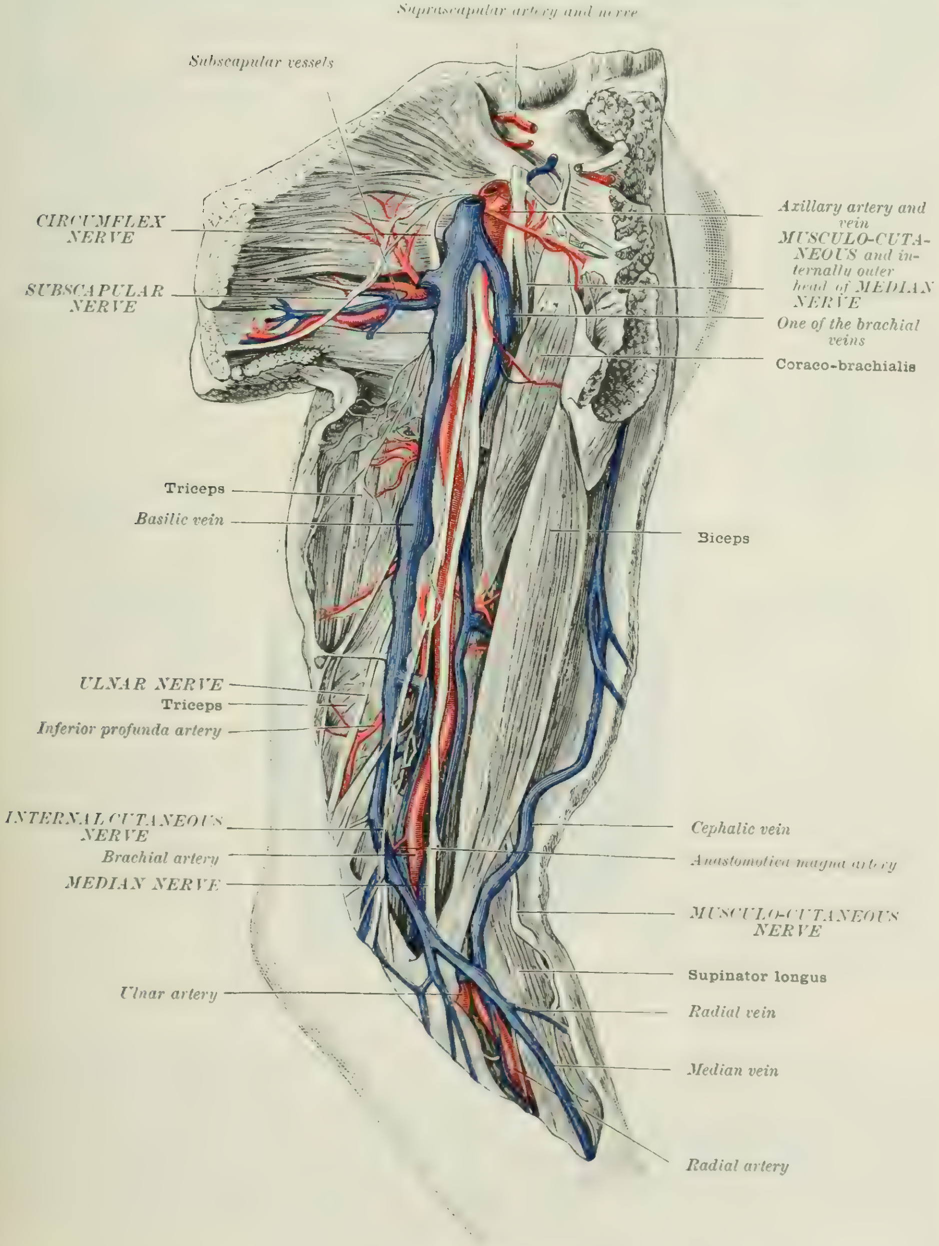
THE BRACHIAL ARTERY

The **brachial artery,** the continuation of the axillary, extends from the lower border of the teres major to a little below the centre of the crease at the bend of the elbow, where it divides, opposite the junction of the head with the neck of the radius, into the radial and ulnar arteries. The artery is situated at first internal to the humerus; but as it passes down the arm it gradually gets in front of the bone, and at the bend of the elbow lies midway between the two condyles (fig. 350). Hence, in controlling hæmorrhage, the artery should be compressed outwards against the bone in its upper third, outwards and backwards in its middle third, and directly backwards in its lower third. Throughout the greater part of its course the artery is superficial, being merely overlapped slightly on its outer side by the coraco-brachialis and biceps muscles; but at the bend of the elbow it sinks deeply beneath the semilunar fascia of the biceps into the triangular interval (antecubital space), bounded on either side by the supinator longus and pronator radii teres, and at its bifurcation is more or less under cover of these muscles (fig. 351). The sheath of the brachial artery is closely incorporated with the fascia covering the biceps muscle, and it is for this reason that in the operation for ligaturing, the vessel is apt to be retracted with the muscle. A line drawn from midway between the folds of the axilla at the outer side of that space to midway between the condyles of the humerus, will indicate its course. It is accompanied by two veins which frequently communicate across the artery.

Relations.—In front, the artery is covered by the integuments and superficial and deep fasciæ, and at the bend of the elbow by the semilunar fascia of the biceps, and in muscular subjects by the overlapping margins of the supinator longus and

FIG. 350.—THE BRACHIAL ARTERY, LEFT SIDE.

(From a dissection in the Museum of the Royal College of Surgeons.)


Suprascapular artery and nerve
Subscapular vessels
CIRCUMFLEX NERVE
SUBSCAPULAR NERVE
Axillary artery and vein
MUSCULO-CUTANEOUS and internally outer head of MEDIAN NERVE
One of the brachial veins
Coraco-brachialis
Triceps
Basilic vein
Biceps
ULNAR NERVE
Triceps
Inferior profunda artery
INTERNAL CUTANEOUS NERVE
Brachial artery
MEDIAN NERVE
Cephalic vein
Anastomotica magna artery
MUSCULO-CUTANEOUS NERVE
Supinator longus
Ulnar artery
Radial vein
Median vein
Radial artery

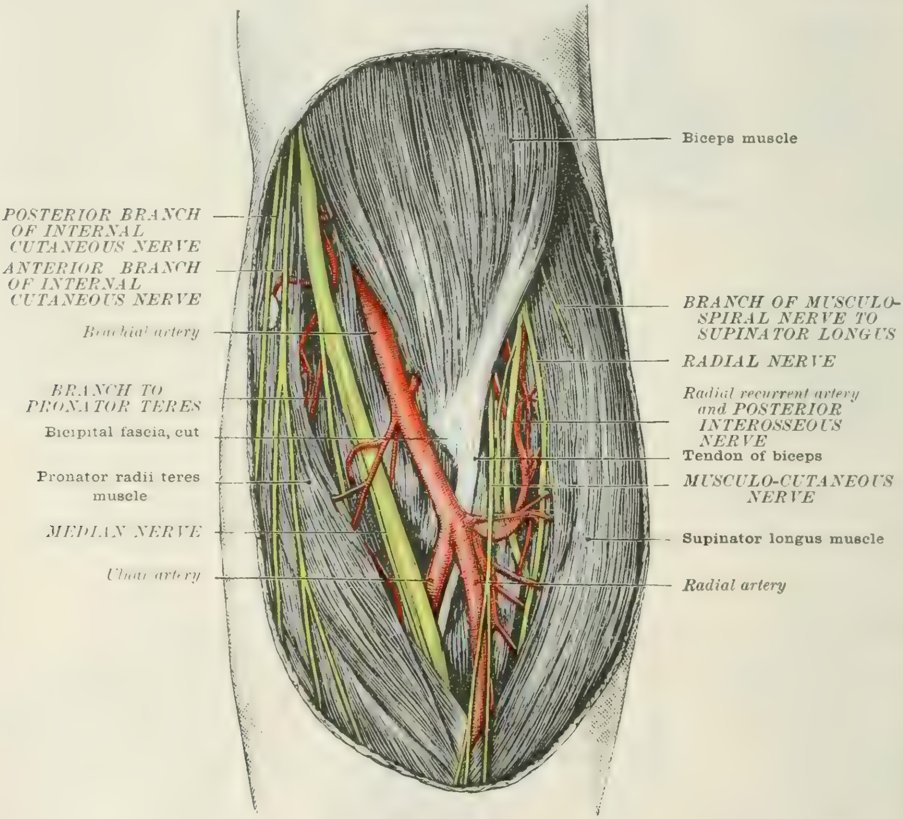
pronator radii teres. In the middle third of the arm it is crossed obliquely from without inwards by the median nerve, and at the bend of the elbow by the median basilic vein, the bicipital fascia intervening (fig. 357).

Behind, it lies successively on the long head of the triceps (from which it is separated by the musculo-spiral nerve and superior profunda artery), on the inner head of the triceps, on the insertion of the coraco-brachialis, and thence to its bifurcation on the brachialis anticus muscle.

External to the artery is the coraco-brachialis above, and the muscular belly of the biceps below, both of which slightly overlap the vessel, and at the bend of the elbow the tendon of the biceps. The external vena comes is also to its outer side. The median nerve is in close contact with the outer side of the artery in the upper third of its course, but in the middle third crosses the artery obliquely to gain the inner side.

Internal to the artery in the upper part of its course are the internal cutaneous and the ulnar nerves; the latter nerve, however, leaves the artery about the origin of the inferior profunda branch, to make, with that vessel, for the internal condyle. Lower down, the internal cutaneous nerve also leaves the artery, by piercing the deep fascia. The median nerve is in close contact with the inner side of the artery in its lower third and at the bend of the elbow. The basilic vein is superficial to it, and a little to its inner side in the greater part of its course, but separated from it by the deep fascia. The internal vena comes runs along its inner side.

Fig. 351.—The Brachial Artery at the Bend of the Elbow, Left Side, Front View.


Biceps muscle
POSTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
ANTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
Brachial artery
BRANCH OF MUSCULO-SPIRAL NERVE TO SUPINATOR LONGUS
RADIAL NERVE
BRANCH TO PRONATOR TERES
Radial recurrent artery and POSTERIOR INTEROSSEOUS NERVE
Bicipital fascia, cut
Tendon of biceps
Pronator radii teres muscle
MUSCULO-CUTANEOUS NERVE
MEDIAN NERVE
Supinator longus muscle
Ulnar artery
Radial artery

The Variations in the Brachial Artery

The **chief variations in the brachial artery** are:—(1) **A high division** into its terminal branches. The high division may occur at any spot in the normal course of the vessel, but is most common in the upper third of the arm, and least common in the middle third. The two vessels into which the brachial then divides as a rule run parallel to each other to the bend of the elbow in the usual situation of the brachial, whence one follows the normal course of the radial artery through the forearm, and the other takes the normal course of the ulnar artery, giving off as usual the common interosseous artery. This arrangement may be considered a **simple high division** of the brachial. At other times the disposition of the two vessels is different: thus (i) the two arteries may communicate at the elbow by a cross branch, or reunite, and then again divide in the usual manner. (ii) One vessel may follow the course of the ulnar artery in the forearm, and the other divide into the radial and common interosseous. This condition is spoken of as a high origin of the ulnar. (iii) One artery may divide into the radial and ulnar as usual, and the other take the course of the common interosseous and divide into the anterior and posterior interosseous arteries; or, much more rarely, take the course of the posterior interosseous artery, the anterior interosseous coming from the ulnar. (iv) The vessels may follow a course in the upper arm different from that of the normal brachial. Thus (A) the branch representing the radial may (*a*) cross over or under the other branch; (*b*) perforate the deep fascia above the elbow, and run beneath the skin to its place in the forearm; or (*c*) pass behind the tendon of the biceps. (B) The branch representing the ulnar may (*a*) run to the front of the inner condyle with the median nerve, and thence reach its usual situation by descending from within outwards beneath the fascia and pronator teres, or, more rarely, beneath some of the flexor muscles, or merely beneath the skin; or (*b*) it may run with the ulnar nerve behind the inner condyle, and thence beneath the muscles to its usual place in the forearm. (2) An **enlarged vas aberrans** may be present. This is a long slender vessel, which arises from the brachial usually near the origin of the superior profunda, and joins most commonly the radial artery, or, more rarely, one of its branches, or the ulnar. It is said to be usually present, though not admitting of complete injection, and to descend over the median nerve to the biceps muscle. At times this vessel takes the place of the brachial; the median nerve will then be found behind the artery. (3) The brachial may run with the median nerve towards the inner condyle, where it then usually turns round a supracondyloid process after the course normally taken by the artery in the Felidæ, in which it runs through a supracondyloid foramen. Thence it descends to its normal situation beneath the pronator teres, which then usually arises from a fibrous expansion from the process. (4) The brachial may be covered by various muscular slips derived from the adjacent muscles. (5) Certain abnormalities in the giving off of its collateral branches. These are referred to under each branch.

BRANCHES OF THE BRACHIAL ARTERY

The **branches of the brachial artery** are:—(1) The superior profunda; (2) the inferior profunda; (3) the anastomotica magna; (4) the nutrient; (5) the muscular; and (6) the terminal branches—the radial and ulnar arteries.

(1) THE SUPERIOR PROFUNDA ARTERY

The **superior profunda** is the largest of the branches of the brachial. It arises from the inner and hinder aspect of that artery, a little below the inferior border of the tendon of the teres major. It at first lies to the inner side of the brachial, but soon passes behind that vessel, and, sinking between the inner and long heads of the triceps with the musculo-spiral nerve, curves round the humerus in the musculo-spiral groove, lying in contact with the bone between the inner and outer heads of the triceps. On reaching the external supracondyloid ridge of the humerus, it perforates the external intermuscular septum, and, continuing forward between the supinator longus and brachialis anticus to the front of the external condyle, ends by anastomosing with the radial recurrent artery.

It gives off the following branches:—

(*a*) The **ascending branch**, which runs upwards behind the tendon of the teres major in the substance of the triceps, or between the outer and inner heads of that muscle, to anastomose with the tricipital branch of the posterior circumflex artery. The importance of this anastomosis in carrying on the collateral circulation after ligature of the third part of the axillary artery below the circumflex, or the brachial above the profunda, has already been mentioned (page 526).

(*b*) The **cutaneous branch**, which runs with the external cutaneous branch of the musculo-spiral nerve to supply the skin of the outer side of the arm.

(*c*) The **articular branch**, which is often larger than the continued trunk of the superior profunda itself, is given off from the artery just before it perforates the intermuscular septum, runs downwards in the substance of the triceps to the back of the external condyle, where it anastomoses with the interosseous recurrent, and forms an arterial arch by anastomosing with the anastomotica magna across the back of the lower end of the humerus immediately above the olecranon fossa. From this arch or rete small twigs enter and supply the elbow-joint.

(*d*) A **nutrient artery** is sometimes given to the upper end of the humerus.

(*e*) **Muscular branches** to the triceps.

Chief variations.—The **superior profunda** may arise (*a*) from the axillary artery in common with one or more branches of that vessel; or (*b*) as a common trunk with the inferior profunda. (*c*) It may give off the posterior circumflex, which then runs upwards behind the teres major to reach the back of the shoulder.

(2) THE INFERIOR PROFUNDA ARTERY

The **inferior profunda** arises from the inner side of the brachial, usually about the level of the insertion of the coraco-brachialis, at times as a common trunk with the superior profunda. It passes with the ulnar nerve obliquely downwards and inwards through the internal intermuscular septum, and then along the inner head of the triceps to the back of the internal condyle where, under cover of the deep fascia and the origin of the flexor carpi ulnaris from the olecranon and internal condyle, it anastomoses with the posterior ulnar recurrent and anastomotica magna arteries. It frequently supplies the nutrient artery to the humerus. It gives branches to the triceps, to the elbow-joint, and a branch which passes in front of the internal condyle to anastomose with the anterior ulnar recurrent.

Chief variations.—(1) The **inferior profunda** may arise (*a*) with the superior profunda; (*b*) from a trunk common to several other branches of the axillary and brachial arteries. (2) It may be absent, its place being taken by the anastomotica magna.

(3) THE ANASTOMOTICA MAGNA ARTERY

The **anastomotica magna** arises from the inner side of the brachial, about two inches above its bifurcation into the radial and ulnar arteries, and, running downwards and inwards across the brachialis anticus, divides into two branches, a posterior and an anterior. The **posterior** pierces the internal intermuscular septum, winds round the internal condyloid ridge of the humerus, and pierces the triceps, between which and the bone it anastomoses with the articular branch of the superior profunda artery, and to a lesser extent with the interosseous recurrent, forming an arterial arch or rete round the upper border of the olecranon fossa. The **anterior** branch passes downwards and inwards between the brachialis anticus and pronator teres, and anastomoses in front of the internal condyle, but beneath the pronator teres, with the anterior ulnar recurrent. From this branch a small vessel passes down behind the internal condyle to anastomose with the posterior ulnar recurrent and inferior profunda arteries.

Chief variations.—(*a*) The **anastomotica magna** may take the place of the inferior profunda. (*b*) It may be very small, the inferior profunda taking its place.

(4) THE NUTRIENT ARTERY OF THE HUMERUS

The **nutrient artery of the humerus** comes off from the brachial about the level of the insertion of the coraco-brachialis, or from the inferior profunda, or from one of the muscular branches. It passes obliquely downwards through the nutrient foramen, and on entering the medullary canal of the humerus divides into an ascending and a descending branch, of which the latter is the larger.

(5) THE MUSCULAR BRANCHES OF THE BRACHIAL

The **muscular branches** are irregular in their number, origin, and distribution. They vary from about five to eight, usually come off from the outer part of the artery, and are distributed to the coraco-brachialis, biceps, and brachialis anticus muscles. The nutrient artery of the humerus frequently arises from the uppermost muscular branch.

THE ULNAR ARTERY

The **ulnar artery,** the larger of the two terminal branches of the brachial, begins opposite the lower border of the head of the radius in the middle line of the forearm. Thence through the upper half of the forearm it runs in a slight curve, with its convexity inwards, deeply beneath the pronator teres and superficial flexor muscles, and, having reached the ulnar side of the limb about midway between the elbow and the wrist, it passes directly downwards, being merely overlapped by the flexor carpi ulnaris. Crossing the annular ligament immediately to the radial side of the pisiform bone, it enters the palm, where it divides into two branches, which enter respectively into the formation of the superficial and deep palmar arches. The artery is accompanied by two veins, which anastomose with each other by frequent cross branches, and usually terminate in the brachial venæ comites; or sometimes the inner vena comes ends in the inner brachial vein, the outer vena comes in the median profunda vein. The ulnar nerve is at first some distance from the artery, but approaches the vessel at the junction of its upper and middle thirds, and then lies close to its inner or ulnar side. The course of the artery in the lower two-thirds of the forearm is indicated by a line drawn from the front of the internal condyle to the radial side of the pisiform bone; and in the upper third of the forearm by a line drawn in a gentle curve with its convexity inwards from an inch below the centre of the bend of the elbow to a point in the former line at the junction of its upper with its middle third. The artery throughout its course is best reached through the innermost intermuscular septum, i.e. the interval between the flexor carpi ulnaris and the flexor sublimis digitorum.

The relations of the artery will be given in detail—as it lies in the forearm, at the wrist, and in the palm of the hand.

I. RELATIONS OF THE ULNAR ARTERY IN THE FOREARM

In front.—In the upper half of the forearm the ulnar artery is deeply placed beneath the pronator teres, the flexor carpi radialis, the palmaris longus, and the flexor sublimis digitorum. In the lower half it is comparatively superficial, being merely overlapped above by the tendon of the flexor carpi ulnaris, whilst the last inch or so of the vessel is only covered as a rule by the skin and superficial and deep fasciæ. As the artery lies beneath the pronator teres, it is crossed from within outwards by the median nerve, the deep head of origin of the muscle usually separating the nerve from the artery. The lower part of the artery is crossed by the palmar cutaneous branch of the ulnar nerve.

Behind.—For about an inch of its course the artery lies upon the brachialis anticus; but thence, as far as the anterior annular ligament of the wrist, upon the flexor profundus digitorum, which separates it above from the interosseous membrane and bone, and at the wrist from the pronator quadratus. The artery is bound down to the flexor profundus digitorum by bands of fasciæ.

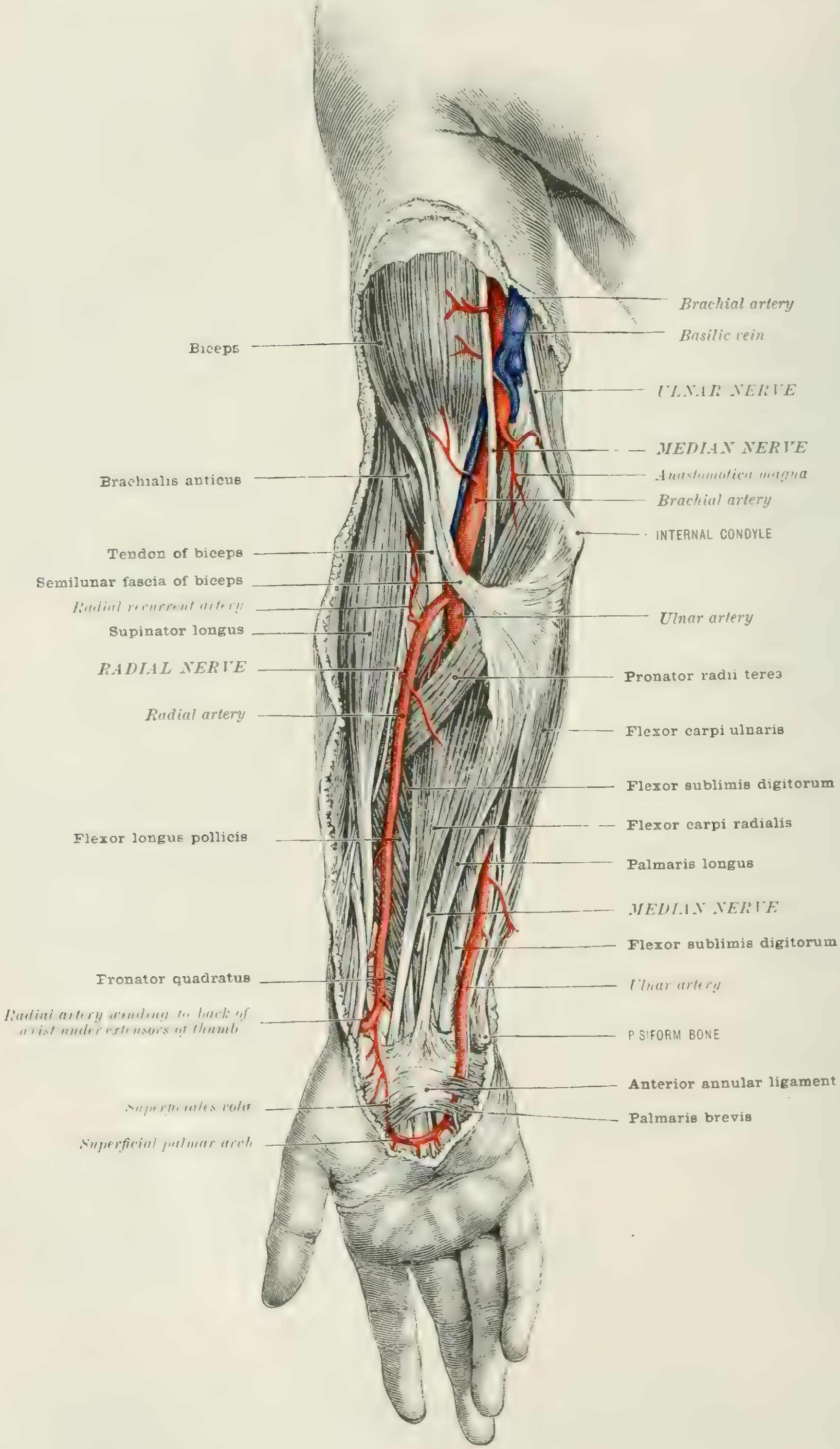
To the **outer side** in the lower two-thirds of its course is the flexor sublimis digitorum.

To the **inner side** in the lower two-thirds is the flexor carpi ulnaris, the guide to the vessel. The ulnar nerve, as it enters the forearm from behind the inner condyle, is at first some distance from the artery, being separated from it in its upper third by the flexor sublimis digitorum, but in its lower two-thirds is in close contact with the vessel and on its ulnar side.

Variations of the Ulnar Artery in the Forearm

The **principal variations of the ulnar artery in the forearm** are: (A) It may arise from the brachial above the usual point of division or from the axillary, in which case it usually runs over the flexor muscles, but beneath the fascia, to reach its usual situation in the forearm. The recurrent arteries and the common interosseous are then usually derived from the trunk vessel from

FIG. 352.—THE ARTERIES OF THE FOREARM WITH THE SUPERFICIAL PALMAR ARCH.


Brachial artery
Basilic vein
Biceps
ULNAR NERVE
MEDIAN NERVE
Anastomotica magna
Brachialis anticus
Brachial artery
INTERNAL CONDYLE
Tendon of biceps
Semilunar fascia of biceps
Radial recurrent artery
Ulnar artery
Supinator longus
RADIAL NERVE
Pronator radii teres
Radial artery
Flexor carpi ulnaris
Flexor sublimis digitorum
Flexor carpi radialis
Flexor longus pollicis
Palmaris longus
MEDIAN NERVE
Flexor sublimis digitorum
Pronator quadratus
Ulnar artery
Radial artery winding to back of wrist under extensors of thumb
PISIFORM BONE
Anterior annular ligament
Superficialis volæ
Palmaris brevis
Superficial palmar arch

which the ulnar is given off. At times it runs beneath the muscles, or merely beneath the skin. (B) It may in some cases of high division of the brachial run beneath the fascia throughout its whole extent in the forearm. (C) In some cases of normal origin from the brachial it takes a superficial course in the forearm, being merely covered by the fascia, the recurrent branches and the common interosseous then arising from the radial.

The **branches of the ulnar artery in the forearm** are:—1. The anterior ulnar recurrent. 2. The posterior ulnar recurrent. 3. The interosseous, or common interosseous: (*a*) anterior interosseous—(i) arteria comes nervi mediani, (ii) muscular, (iii) medullary, (iv) anterior communicating; (*b*) posterior interosseous—(i) interosseous recurrent, (ii) muscular, (iii) articular. 4. Muscular. 5. Nutrient. 6. Posterior ulnar carpal. 7. Anterior ulnar carpal.

1. The **anterior ulnar recurrent** is a small branch which leaves the inner side of the ulnar artery soon after its origin, and, running upwards and inwards between the outer edge of the pronator teres and the brachialis anticus, anastomoses in front of the internal condyle with the anastomotica magna and a branch of the inferior profunda artery. It supplies branches to the muscles between which it runs.

2. The **posterior ulnar recurrent,** larger than the anterior ulnar recurrent, comes off from the inner side of the ulnar artery, either a little below the latter branch, or else as a common trunk with it, and, passing inwards between the flexor sublimis and flexor profundus digitorum, turns upwards to the back of the internal condyle, where it lies with the ulnar nerve between the two heads of origin of the flexor carpi ulnaris. It supplies the contiguous muscles—the flexor carpi ulnaris, the palmaris longus, and the flexor sublimis and profundus digitorum—the elbow-joint and the ulnar nerve, and anastomoses with the inferior profunda, with the anastomotica magna, and with the interosseous recurrent, forming the so-called rete olecrani.

3. The **interosseous** or **common interosseous artery,** is a short thick trunk half an inch or so in length, which comes off from the outer and back part of the ulnar artery about an inch from its origin, and just before that artery is crossed by the median nerve. It passes backwards and downwards between the flexor longus pollicis and the flexor profundus digitorum, towards the triangular interval bounded by the upper border of the interosseous membrane, the oblique ligament, and the outer border of the ulna, where it divides into the anterior and posterior interosseous arteries.

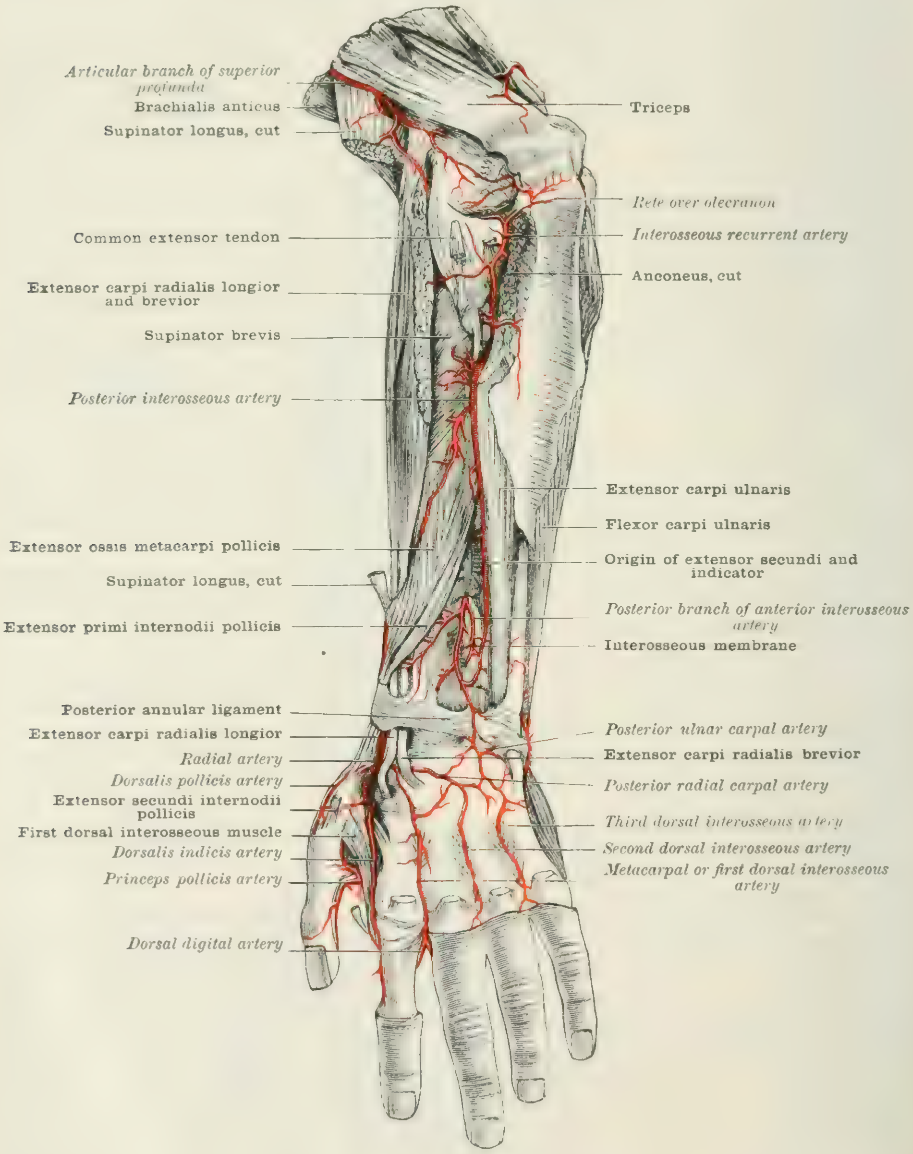
(*a*) The **anterior interosseous artery,** smaller than the posterior, but apparently the direct continuation of the common trunk, courses downwards in front of the interosseous membrane, upon which it lies under cover of the overlapping edges of the flexor profundus digitorum and flexor longus pollicis, to the upper border of the pronator quadratus, where it terminates in two branches, an anterior terminal and a posterior terminal.

The anterior interosseous artery is accompanied by two veins and by the deep branch of the median nerve which lies to its radial side. The artery is bound down to the interosseous membrane by aponeurotic fibres.

The **branches of the anterior interosseous artery** are:—(1) The **arteria comes nervi mediani**—or the **median** artery as it is sometimes shortly called—is a long slender vessel, which arises from the anterior interosseous immediately after the latter is given off from the common trunk. It passes forwards between the flexor profundus digitorum and the flexor longus pollicis to the median nerve, with which it descends beneath the annular ligament into the palm, and when of large size sometimes enters into the formation of the superficial palmar arch. At times the artery arises from the common interosseous before its division. (ii) **Muscular branches** supply the flexor longus pollicis, flexor profundus digitorum, and pronator quadratus, and the extensor muscles of the thumb, which they reach by passing backwards through the interosseous membrane. (iii) The **nutrient arteries** of the radius and ulna are usually derived from this vessel. (iv) The **anterior terminal** and smaller division of the anterior interosseous artery, sometimes called the anterior communicating, passes either in front of or behind the pronator quadratus, but in either case in front of the interosseous membrane, and anastomoses with the anterior carpal branches of the radial and ulnar arteries, and with the recurrent branches from the deep palmar arch, forming the so-called **anterior carpal rete.** (v) The **posterior terminal** and larger division pierces the interosseous membrane, and continues its course downwards behind the interosseous membrane, under cover of the extensor muscles, to the back of the wrist, where it ends by anastomosing with the posterior carpal branches of the radial and ulnar arteries, forming the so-called **posterior carpal rete.** This branch anastomoses, as soon as it pierces the interosseous membrane, with the posterior interosseous artery.

FIG. 353.—THE BACK OF THE LEFT FOREARM, WITH THE POSTERIOR INTEROSSEOUS ARTERY AND BRANCHES OF THE RADIAL AT THE BACK OF THE WRIST.

(From a dissection in the Hunterian Museum.)



Articular branch of superior profunda
Brachialis anticus
Supinator longus, cut
Triceps
Rete over olecranon
Interosseous recurrent artery
Common extensor tendon
Anconeus, cut
Extensor carpi radialis longior and brevior
Supinator brevis
Posterior interosseous artery
Extensor carpi ulnaris
Flexor carpi ulnaris
Extensor ossis metacarpi pollicis
Origin of extensor secundi and indicator
Supinator longus, cut
Posterior branch of anterior interosseous artery
Extensor primi internodii pollicis
Interosseous membrane
Posterior annular ligament
Posterior ulnar carpal artery
Extensor carpi radialis longior
Radial artery
Extensor carpi radialis brevior
Dorsalis pollicis artery
Posterior radial carpal artery
Extensor secundi internodii pollicis
Third dorsal interosseous artery
First dorsal interosseous muscle
Second dorsal interosseous artery
Dorsalis indicis artery
Metacarpal or first dorsal interosseous artery
Princeps pollicis artery
Dorsal digital artery

(*b*) The **posterior interosseous artery,** the larger division of the common interosseous, turns backwards through the triangular interval bounded by the interosseous membrane below, the oblique ligament above, and the ulna internally, and, emerging at the back of the forearm between the extensor ossis metacarpi pollicis and the supinator brevis, under cover of the superficial extensors of the forearm, descends between the superficial and the deep muscles, crossing in this course the extensor ossis metacarpi pollicis, the extensor primi internodii pollicis, the extensor secundi internodii pollicis, and the indicator (fig. 353). It anastomoses at the lower border of this muscle with the anterior interosseous, or with the posterior branch of the anterior interosseous which here, as above described, has perforated the interosseous membrane. It is separated from the nerve of the same name at first by the radius and supinator brevis and on the back of the forearm by the extensores secundi internodii pollicis and indicis.

It gives off the following branches:—(i) The **interosseous recurrent,** or **posterior interosseous recurrent** (fig. 353), arises from the posterior interosseous as the latter emerges from beneath the supinator brevis. It runs upwards between the anconeus and supinator brevis, usually under cover of the former, to the interval between the external condyle and the olecranon, where it anastomoses with the superior profunda, anastomotica magna, radial recurrent, and posterior ulnar recurrent arteries, and gives branches to the retiform plexus over the olecranon—the rete olecrani. (ii) **Muscular branches** are given off to the superficial and deep extensor muscles. (iii) **Articular branches** enter the back of the wrist-joint.

4. The **muscular branches of the ulnar artery** supply the contiguous muscles, and are variable in number, origin, and distribution.

5. The **nutrient artery of the ulna** may be given off from the main trunk of the ulnar artery, or from one of its muscular branches, or from the anterior interosseous artery.

6. The **posterior ulnar carpal** comes off from the ulnar artery a little above the anterior annular ligament, and, winding inwards round the end of the ulna or the internal lateral ligament of the wrist, beneath the flexor carpi ulnaris, ramifies on the back of the carpus beneath the extensor tendons. It forms by its anastomosis with the posterior radial carpal and with the posterior branch of the anterior interosseous and with the posterior interosseous arteries, a plexus or rete, the so-called posterior carpal arch. The branches given off from this plexus or arch are described with the posterior carpal branch of the radial artery (page 541).

7. The **anterior ulnar carpal** is a small branch given off from the ulnar artery opposite the carpus. It passes beneath the flexor profundus digitorum to anastomose with the anterior radial carpal, with terminal twigs of the anterior branch of the anterior interosseous, and with recurrent branches from the deep palmar arch, forming an anastomotic arch across the front of the carpus—the so-called **anterior carpal arch** or **rete.**

II. Relations of the Ulnar Artery at the Wrist

The **ulnar artery at the wrist** may be said to extend from the upper to the lower border of the anterior annular ligament. It here lies immediately to the radial side of the pisiform bone, and to the ulnar side of the hook of the unciform, the two bones forming for the vessel a protecting channel, which is further converted into a short canal by the expansion of the flexor carpi ulnaris passing from the pisiform to the hook of the unciform. The ulnar nerve in this situation is immediately to the ulnar side of the artery.

Relations.—In front it has, in addition to the expansion above mentioned, the skin and superficial fascia; **below,** it rests on the annular ligament; **internally** are the ulnar nerve and pisiform bone; **externally,** the hook of the unciform.

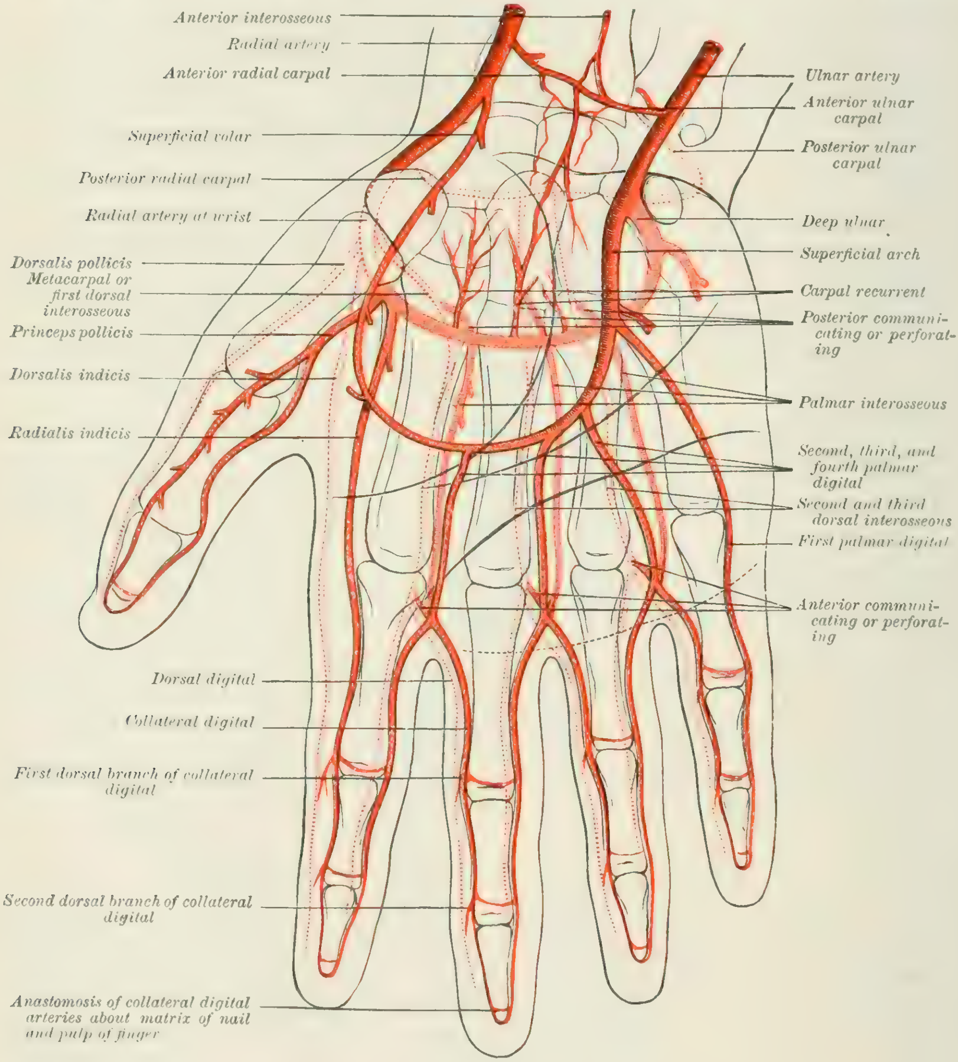
The ulnar artery gives off no named branch in this part of its course.

III. Relations of the Ulnar Artery in the Palm (Superficial Palmar Arch)

The ulnar artery, on entering the palm, divides into two branches, the superficial and deep.

The **superficial branch** (fig. 354), the direct continuation of the vessel, anastomoses with the superficial volar, a branch of the radial, forming what is then known as the **superficial palmar arch.** After descending a short distance towards the cleft between the fourth and fifth fingers, it turns outwards towards the thumb, forming a curve with its convexity towards the fingers and its concavity towards the muscles of the thumb, and anastomoses opposite the cleft between the index and middle fingers, at the junction of the upper with the middle third of the palm, with the superficial volar branch of the radial artery to complete the arch. A line drawn across the palm on a level with the thumb at a right angle to the hand will roughly indicate the situation of the arch.

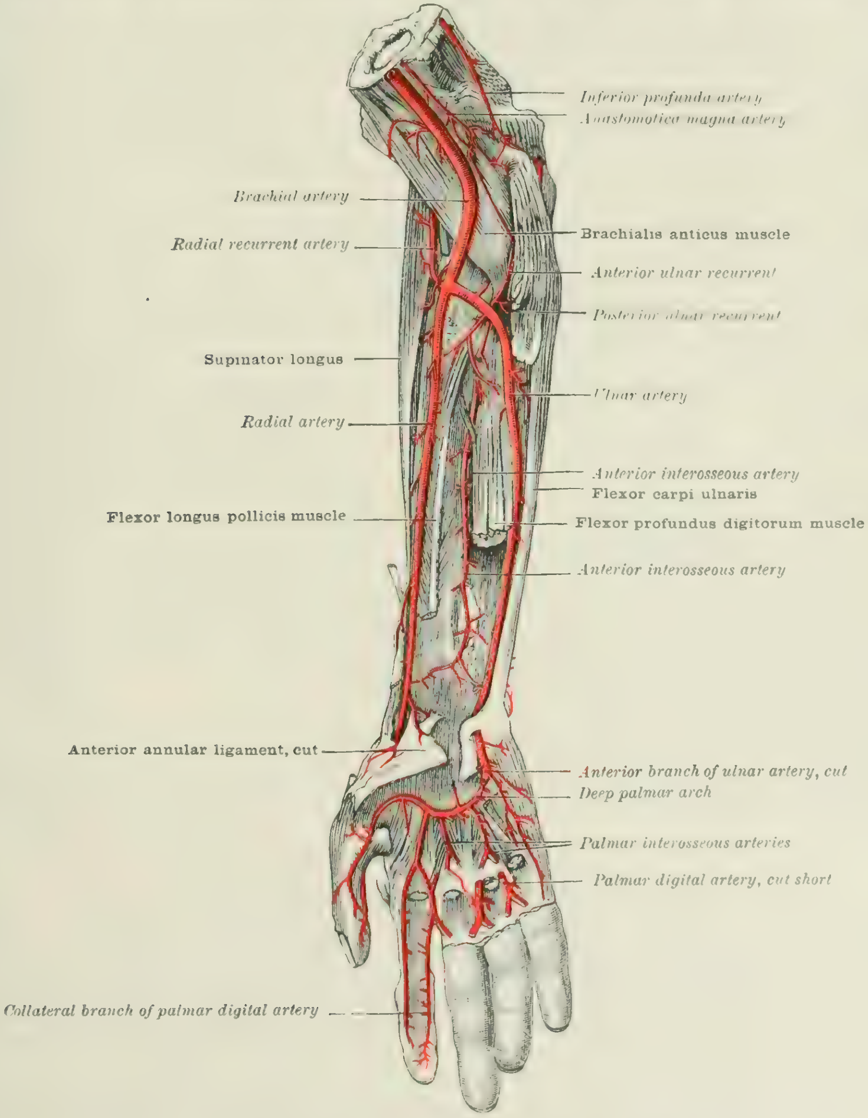
Fig. 354.—Anastomoses and Distribution of the Arteries of the Hand. (Walsham.)


Anterior interosseous
Radial artery
Anterior radial carpal
Superficial volar
Posterior radial carpal
Radial artery at wrist
Dorsalis pollicis
Metacarpal or first dorsal interosseous
Princeps pollicis
Dorsalis indicis
Radialis indicis
Dorsal digital
Collateral digital
First dorsal branch of collateral digital
Second dorsal branch of collateral digital
Anastomosis of collateral digital arteries about matrix of nail and pulp of finger
Ulnar artery
Anterior ulnar carpal
Posterior ulnar carpal
Deep ulnar
Superficial arch
Carpal recurrent
Posterior communicating or perforating
Palmar interosseous
Second, third, and fourth palmar digital
Second and third dorsal interosseous
First palmar digital
Anterior communicating or perforating

Relations.—In front: in addition to the skin and superficial fascia, the vessel is crossed successively, from within outwards, by the palmaris brevis, the palmar branch of the ulnar nerve, the palmar fascia, and the palmar branch of the median nerve.

Behind, it rests upon, from within outwards, the short muscles of the little finger, the digital branches of the ulnar nerve, the flexor tendons, and the digital branches of the median nerve.

FIG. 355.—THE ARTERIES OF THE RIGHT FOREARM AND THE DEEP PALMAR ARCH.


Inferior profunda artery
Anastomotica magna artery
Brachial artery
Brachialis anticus muscle
Radial recurrent artery
Anterior ulnar recurrent
Posterior ulnar recurrent
Supinator longus
Ulnar artery
Radial artery
Anterior interosseous artery
Flexor carpi ulnaris
Flexor longus pollicis muscle
Flexor profundus digitorum muscle
Anterior interosseous artery
Anterior annular ligament, cut
Anterior branch of ulnar artery, cut
Deep palmar arch
Palmar interosseous arteries
Palmar digital artery, cut short
Collateral branch of palmar digital artery

Variations in the Superficial Palmar Arch

The superficial palmar arch is very subject to variations. (A) It may be formed by the superficial branch of the ulnar anastomosing with the radialis indicis, or with the radial in the palm instead of with the superficial volar branch of the radial. (B) The superficial volar may be larger than usual, and take a greater share than the ulnar in the formation of the arch. (C) The arch may be reinforced by a large median artery, or by an enlarged interosseous artery. (D) The arch may be double, both the superficial branch of the ulnar and the superficial volar dividing into two branches which anastomose across the palm. (E) The arteries of the thumb and radial side of the index finger may be given off from the arch. (F) The arch may be incomplete, the inner digital branches coming off from the ulnar, and the outer from the superficial volar, the radial in the palm or an enlarged median artery. (G) The arch may be absent, the lateral digital arteries being then given off from enlarged interosseous arteries from the deep arch, or from enlarged dorsal interosseous arteries.

The **branches of the superficial palmar arch** are:—(1) The four digital arteries; (2) the muscular; and (3) the cutaneous.

(1) The **digital arteries,** usually four in number, are given off from the convexity of the superficial arch and, running downwards through the palm, supply both sides of the little, ring, and middle fingers, and the ulnar side of the index finger. The radial side of the index finger and the thumb are supplied respectively by the radialis indicis and princeps pollicis, branches of the radial artery. The digital arteries are named, from within outwards—first, second, third, and fourth. The **first digital artery** runs downwards and inwards over the muscles on the inner side of the palm, and thence along the ulnar side of the little finger. It gives branches to the abductor, flexor brevis, and opponens minimi digiti muscles. This branch sometimes comes from the deep branch of the ulnar artery. The **second, third,** and **fourth digital arteries** run downwards in the interspace between the little and ring, the ring and middle, and the middle and index fingers respectively, to within about a quarter of an inch of the clefts between the fingers, where they divide into two branches (**collateral digital**) for the supply of the sides of the contiguous fingers. As the digital arteries pass through the palm, they lie between the flexor tendons, on the digital nerves and lumbrical muscles, and beneath the palmar fascia. Just before bifurcating they pass under the superficial transverse ligament, and are joined by the palmar interosseous branches from the deep palmar arch (fig. 354). At this spot they also receive the anterior perforating branches from the dorsal interosseous vessels. On the sides of the fingers the collateral digital arteries lie between the palmar and dorsal digital nerves. They anastomose by small branches, forming an arch across the front of the bones on the proximal side of each interphalangeal joint. They supply the flexor tendons and the integuments, and terminate in a plexiform manner beneath the pulp of the finger and around the matrix of the nail. A dorsal digital branch is given off to the back of the fingers about the level of the middle of the first phalanx, and a second but smaller dorsal digital branch about the level of the middle of the second phalanx.

(2) The **muscular branches** from the superficial arch are very small and supply the superficial muscles.

(3) The **cutaneous branches** supply the integuments of the palm.

The **deep branch** of the ulnar artery, also called the communicating artery, sinks deeply into the palm between the abductor and flexor brevis minimi digiti, and joins the radial to form the deep palmar arch. (See THE RADIAL ARTERY, page 543.)

THE RADIAL ARTERY

The **radial artery**—the smaller of the two arteries into which the brachial divides at the bend of the elbow—appears as the direct continuation of the brachial. It runs downwards and outwards along the radial side of the forearm as far as the styloid process, then, coiling over the external lateral ligament and outer and back part of the wrist, enters the palm of the hand from behind between the first and second metacarpal bones, and ends by anastomosing with the deep branch of the ulnar to form the deep palmar arch. Hence the artery is divisible into three parts: that in the forearm, that at the wrist, and that in the palm of the hand. The course of the artery is indicated by a line drawn from a point one inch below the centre of the elbow to a point situated half an inch internal to the styloid process of the radius.

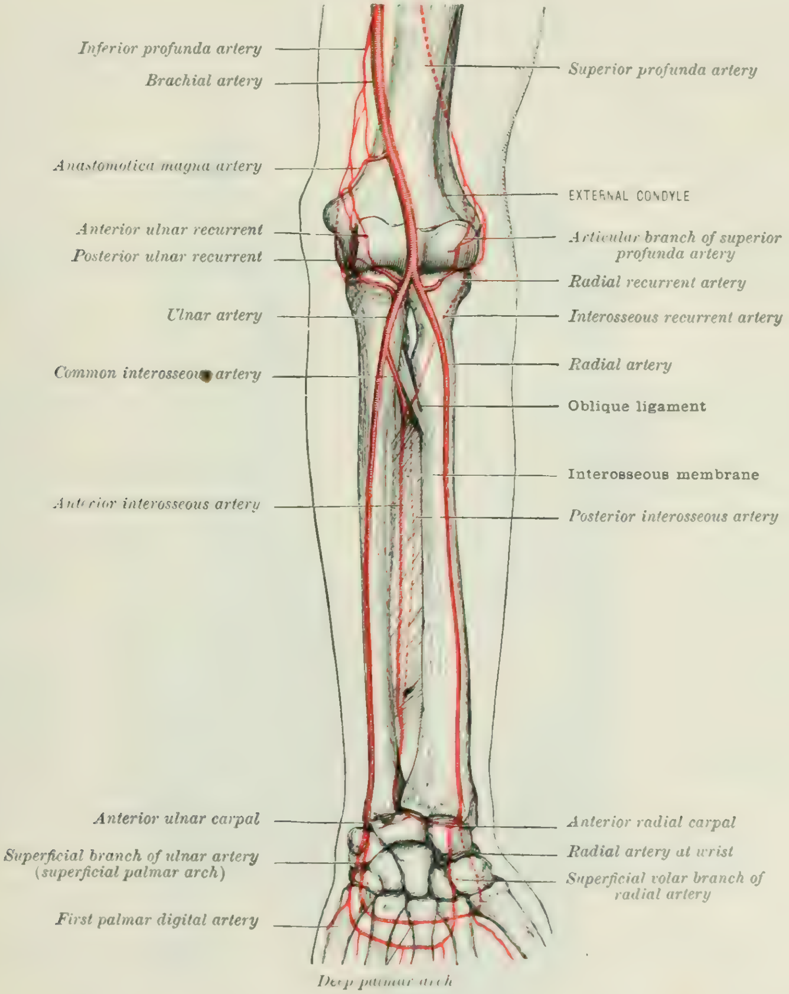
I. THE RADIAL ARTERY IN THE FOREARM

In its course through the forearm (fig. 351) the radial artery is found in the outermost intermuscular space, and it is only necessary to divide the skin, superficial and deep fascia, to expose the vessel, and in addition in the upper third to separate the supinator longus (humero-radialis) from the pronator radii teres.

In front, the artery is at first overlapped by the supinator longus, but for the rest of its course it is merely covered by the skin, superficial and deep fasciæ, by some cutaneous veins, and by cutaneous branches of the musculo-cutaneous nerve.

Behind, it lies successively from above downwards on the tendon of the biceps, the supinator brevis, from which it is separated by a layer of fat, the insertion of the pronator radii teres, the radial origin of the flexor sublimis digitorum, the flexor longus pollicis, the pronator quadratus, and the front surface of the lower end of the radius. It is in this last situation, where the artery lies upon the bone and can therefore be easily pressed against it, that the pulse is usually felt.

FIG. 356.—DIAGRAM OF THE RELATION OF THE ARTERIES OF THE LEFT FOREARM TO THE BONES. (Walsham.)


Inferior profunda artery
Brachial artery
Anastomotica magna artery
Anterior ulnar recurrent
Posterior ulnar recurrent
Ulnar artery
Common interosseous artery
Anterior interosseous artery
Anterior ulnar carpal
Superficial branch of ulnar artery (superficial palmar arch)
First palmar digital artery
Deep palmar arch
Superior profunda artery
EXTERNAL CONDYLE
Articular branch of superior profunda artery
Radial recurrent artery
Interosseous recurrent artery
Radial artery
Oblique ligament
Interosseous membrane
Posterior interosseous artery
Anterior radial carpal
Radial artery at wrist
Superficial volar branch of radial artery

On its **outer side** it has, throughout the whole of its course, the supinator longus or humero-radialis muscle, the guide to the artery in ligature, and the external vena comes; in its middle third, the radial nerve as well. In its lower third the radial nerve is to its outer side, but separated from it by the supinator longus and fascia.

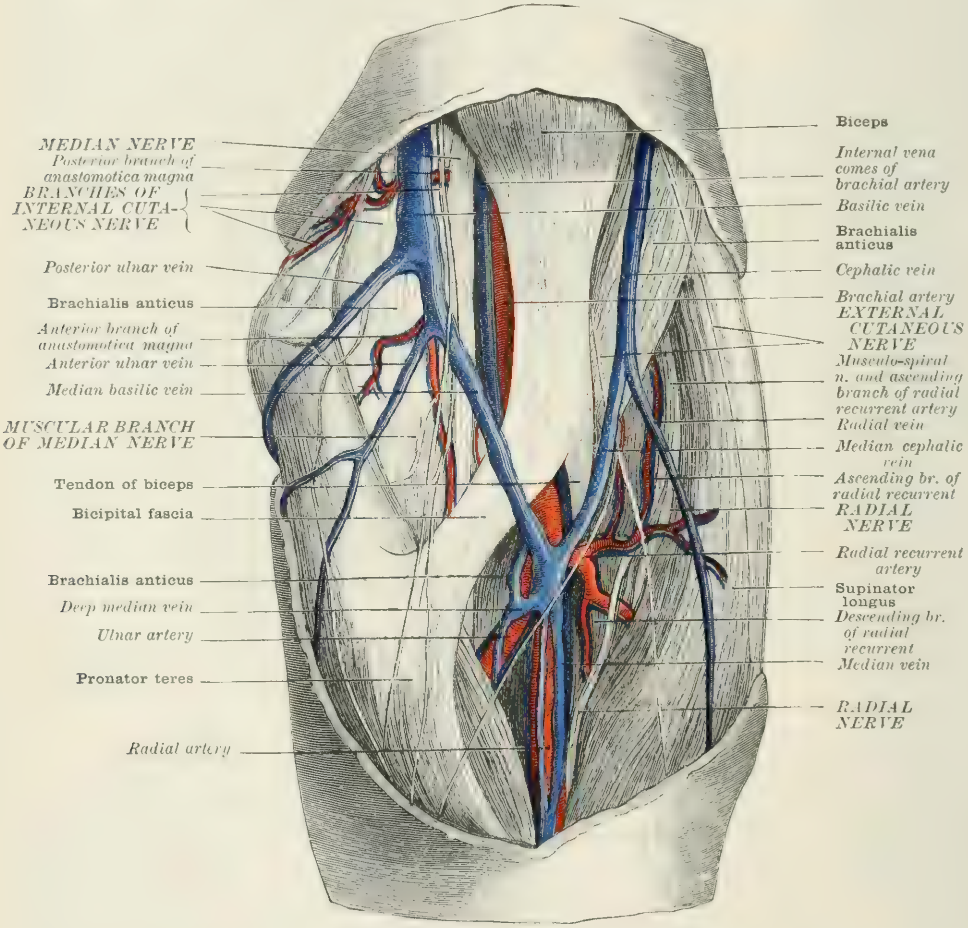
On its **inner side,** in the upper third is the pronator radii teres, in the lower third the tendon of the flexor carpi radialis, and throughout the whole of its course the internal vena comes.

Variations in the Radial Artery in the Forearm

(A) The radial artery may be given off from the brachial higher than usual, or from the axillary artery. (B) It may arise from the brachial lower than the bend of the elbow, but a low division of the brachial is rare. (C) It may run superficial to the fascia of the forearm. (D) It may cross over, instead of under, the extensors of the thumb. (E) It may terminate in the forearm or be absent, its place in the forearm and hand being then supplied by the ulnar, the anterior interosseous, or an enlarged median artery. (F) It may be joined by a vas aberrans from the brachial or axillary artery.

FIG. 357.—THE BEND OF THE ELBOW, LEFT SIDE.

(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)


MEDIAN NERVE
Posterior branch of anastomotica magna
BRANCHES OF INTERNAL CUTANEOUS NERVE
Posterior ulnar vein
Brachialis anticus
Anterior branch of anastomotica magna
Anterior ulnar vein
Median basilic vein
MUSCULAR BRANCH OF MEDIAN NERVE
Tendon of biceps
Bicipital fascia
Brachialis anticus
Deep median vein
Ulnar artery
Pronator teres
Radial artery
Biceps
Internal vena comes of brachial artery
Basilic vein
Brachialis anticus
Cephalic vein
Brachial artery
EXTERNAL CUTANEOUS NERVE
Musculo-spiral n. and ascending branch of radial recurrent artery
Radial vein
Median cephalic vein
Ascending br. of radial recurrent
RADIAL NERVE
Radial recurrent artery
Supinator longus
Descending br. of radial recurrent
Median vein
RADIAL NERVE

The **branches of the radial artery in the forearm** are :—(1) The radial recurrent; (2) the muscular; (3) the anterior radial carpal; (4) the superficial volar.

(1) The **radial recurrent** usually arises from the outer side of the radial just below its origin from the brachial. It at first runs outwards on the supinator brevis, and then divides into three chief branches (fig. 357). One of these runs transversely outwards through the fibres of the musculo-spiral nerve, or between the radial and posterior interosseous nerves when the musculo-spiral divides higher

than usual, into the supinator longus and extensor carpi radialis longior and brevior, and anastomoses with the interosseous recurrent. A **second** ascends between the brachialis anticus and supinator longus, with the musculo-spiral nerve, and anastomoses with the superior profunda artery. A **third** descends with the radial nerve under cover of the supinator longus supplying that muscle. The radial recurrent also gives off branches to the elbow-joint.

(2) The **muscular branches of the radial artery** come off irregularly to supply the contiguous muscles on the outer side of the forearm.

(3) The **anterior radial carpal** arises from the inner side of the radial artery about the level of the lower border of the pronator quadratus. It crosses the front of the radius beneath the flexor muscles, and anastomoses with the anterior carpal branch of the ulnar, forming what is sometimes called the anterior carpal arch; or what is, more properly speaking, an arterial plexus or rete—the anterior carpal rete. This plexus is joined above by small twigs from the anterior interosseous artery, and below by recurrent branches from the deep palmar arch. It supplies branches to the lower end of the radius, and to the wrist and carpal joints.

(4) The **superficial volar** leaves the radial artery as the latter vessel is about to turn over the external lateral ligament to the back of the wrist. It courses forwards over the short muscles of the ball of the thumb, and anastomoses with the superficial branch of the ulnar artery to complete the superficial palmar arch. It supplies small branches to the muscles of the ball of the thumb, and at times terminates in these muscles without joining the arch. Occasionally it passes beneath the abductor pollicis. This branch is often small and ends in the muscles of the thumb.

II. The Radial Artery at the Wrist

The radial artery at the wrist winds over the outer side of the carpus, under the extensor tendons of the thumb, from a spot a little below and internal to the styloid process of the radius to the base of the first interosseous space, where it sinks between the two heads of the abductor indicis into the palm, to form, by anastomosing with the deep branch of the ulnar artery, the deep palmar arch. A line drawn from half an inch internal to the styloid process to the base of the first interosseous space, which can be distinctly felt on the back of the hand, will roughly indicate the course of the artery.

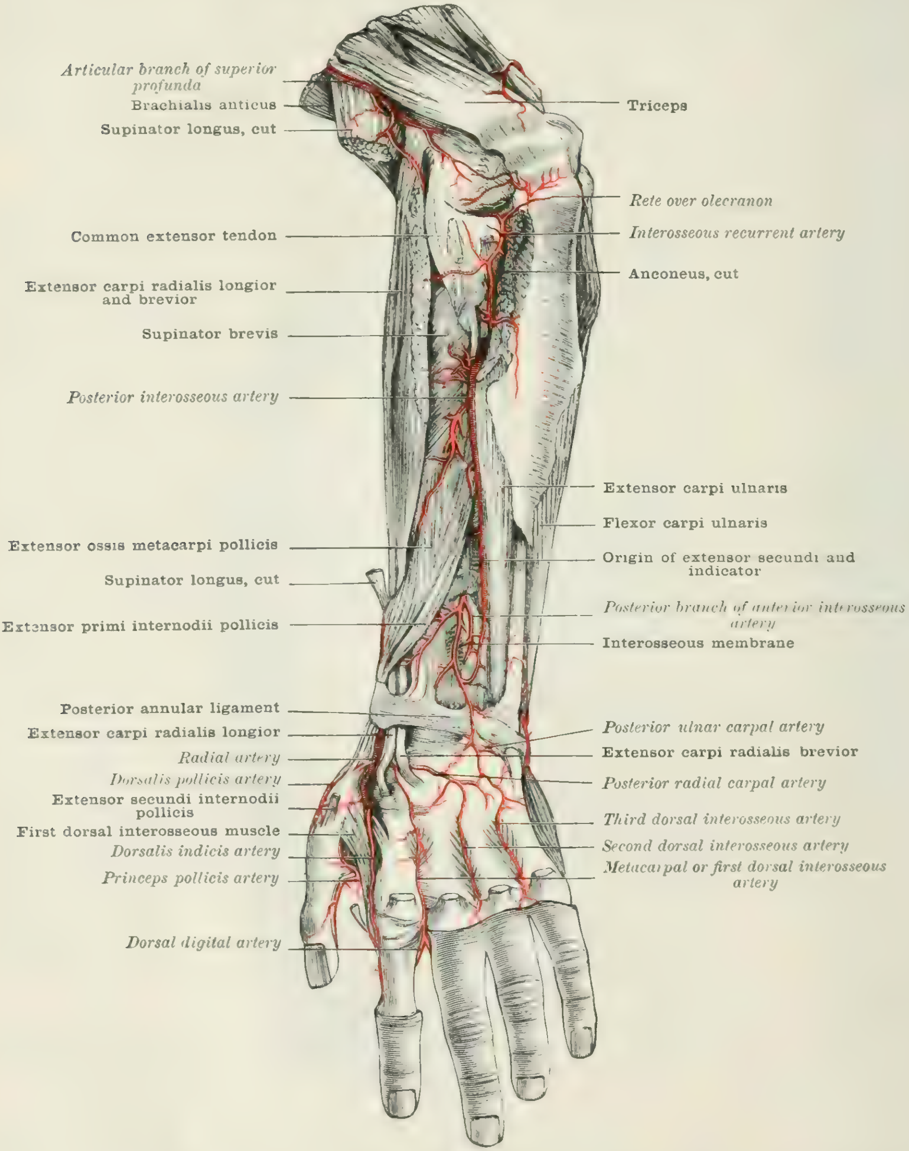
Relations.—The artery is covered successively by the extensor ossis metacarpi pollicis and extensor primi internodii pollicis, by branches of the radial nerve and superficial radial veins, and, just before it sinks between the two heads of the abductor indicis, by the tendon of the extensor secundi internodii pollicis. The branches of the radial nerve to the thumb and index finger cross it. It is at first somewhat deeply placed beneath the first-mentioned extensor muscles of the thumb: but subsequently it lies quite superficial, and can be felt pulsating in a little triangular depression bounded on either side by the extensor primi and extensor secundi internodii pollicis, and above by the lower end of the radius. The artery lies successively on the external lateral ligament of the wrist, on the scaphoid, the trapezium, the base of the first metacarpal bone, and on the dorsal ligaments uniting these bones. It has usually with it two companion veins, and a few branches of the musculo-cutaneous nerve.

The **branches of the radial artery at the wrist** are:—(1) The posterior radial carpal; (2) the metacarpal, or the first dorsal interosseous; (3) the dorsalis pollicis, or dorsal artery of the thumb; and (4) the dorsalis indicis, or dorsal digital artery of the first finger.

(1) The **posterior radial carpal** arises from the radial as the latter vessel passes under the extensor ossis metacarpi pollicis, and runs inwards beneath the extensor carpi radialis longior and brevior, and the extensor secundi internodii pollicis, across the back of the carpus, to anastomose with the posterior ulnar carpal and with the terminal twigs of the posterior branch of the anterior interosseous artery. This anastomosis is called the posterior carpal arch, or posterior carpal rete. The two following named branches are given off from this arch or rete:—(*a*) The **second** and (*b*) the **third dorsal interosseous arteries** to the third and fourth spaces respectively. These vessels run downwards on the dorsal inter-

osseous muscles as far as the flexure of the fingers, and there divide into two branches (**dorsal digital**), which run along the sides of the contiguous fingers on their dorsal aspect. Near their proximal ends they anastomose with the posterior perforating branches of the deep palmar arch. Distally they are connected by anterior perforating branches with the digital arteries of the corresponding spaces.

Fig. 358.—The Radial Artery at the Wrist, Left Forearm.
(From a dissection in the Hunterian Museum.)



Articular branch of superior profunda
Brachialis anticus
Supinator longus, cut
Common extensor tendon
Extensor carpi radialis longior and brevior
Supinator brevis
Posterior interosseous artery
Extensor ossis metacarpi pollicis
Supinator longus, cut
Extensor primi internodii pollicis
Posterior annular ligament
Extensor carpi radialis longior
Radial artery
Dorsalis pollicis artery
Extensor secundi internodii pollicis
First dorsal interosseous muscle
Dorsalis indicis artery
Princeps pollicis artery
Dorsal digital artery
Triceps
Rete over olecranon
Interosseous recurrent artery
Anconeus, cut
Extensor carpi ulnaris
Flexor carpi ulnaris
Origin of extensor secundi and indicator
Posterior branch of anterior interosseous artery
Interosseous membrane
Posterior ulnar carpal artery
Extensor carpi radialis brevior
Posterior radial carpal artery
Third dorsal interosseous artery
Second dorsal interosseous artery
Metacarpal or first dorsal interosseous artery

The branches which run along the backs of the fingers anastomose with the dorsal branches of the collateral digital arteries derived from the palmar digital vessels (fig. 359).

(2) The **metacarpal** or **first dorsal interosseous artery** (figs. 358, 359) arises from the radial artery beneath the extensor secundi internodii pollicis, and, crossing the second metacarpal bone, passes downwards on the second dorsal

interosseous muscle between the extensor tendons to the level of the metacarpo-phalangeal joint, where it divides into two small branches, like the other dorsal interosseous arteries, for the supply of the sides of the contiguous fingers on their dorsal aspect. At the base of the second interosseous space it communicates with the posterior perforating branch of the deep arch, which here runs backwards between the heads of the second dorsal interosseous muscle, and at the fore part of the space it anastomoses through the anterior perforating branch with the fourth digital artery.

The **dorsal digital arteries,** the terminations of the metacarpal artery and dorsal interosseous arteries, extend along the sides of the fingers as far as the first interphalangeal joint, where they anastomose with the dorsal branches of the collateral digital arteries.

(3) The **dorsalis pollicis** arises from the radial just before it sinks between the two heads of the first dorsal interosseous muscle. It runs downwards on the ulnar side of the extensor secundi internodii pollicis, along the metacarpal bone, and divides into two branches for the supply of the radial and ulnar side of the thumb on its dorsal aspect. These branches sometimes come off separately from the radial artery.

(4) The **dorsalis indicis** arises from the radial just as that artery sinks between the two heads of the first dorsal interosseous muscle, usually below the origin of the dorsalis pollicis, but sometimes as a common trunk with the latter vessel. It runs downwards along the radial side of the metacarpal bone of the index finger, and can be traced along the radial side of that finger as far as the first interphalangeal joint, where it anastomoses with the dorsal branch of the radialis indicis.

III. THE RADIAL ARTERY IN THE PALM (THE DEEP PALMAR ARCH)

The radial artery enters the palm between the first and second metacarpal bones at the base of the first interosseous space, by passing between the two heads of the first dorsal interosseous muscle. It then runs inwards between the adductor pollicis and inner head of the flexor brevis pollicis, and continuing its course, in a slight curve with the convexity forwards, across the base of the metacarpal bones and interosseous muscles, it anastomoses with the deep branch of the ulnar, forming the deep palmar arch. The arch thus formed may be said to extend from the first interosseous space to the base of the metacarpal bone of the little finger, and is a finger's breadth nearer the wrist than the superficial arch. It is covered by the superficial and deep flexor tendons, by the inner head of the flexor brevis pollicis, and by part of the flexor brevis minimi digiti. It is accompanied by the deep branch of the ulnar nerve, and two small venæ comites.

Variations in the Deep Palmar Arch

(A) The deep palmar arch may be larger than usual, and its interosseous branches supply the place of one or more of the digital arteries by dividing at the cleft of the fingers into collateral digital branches. (B) It may be reinforced by enlarged posterior perforating branches from the radial and its branches on the back of the hand, or by a large anterior interosseous. (C) The radial may join the deep arch by passing through the second instead of the first interosseous space. (D) The princeps pollicis and radialis indicis may come off from the superficial arch or from the superficial volar, or from a separate branch of the radial which passes through the first interosseous space.

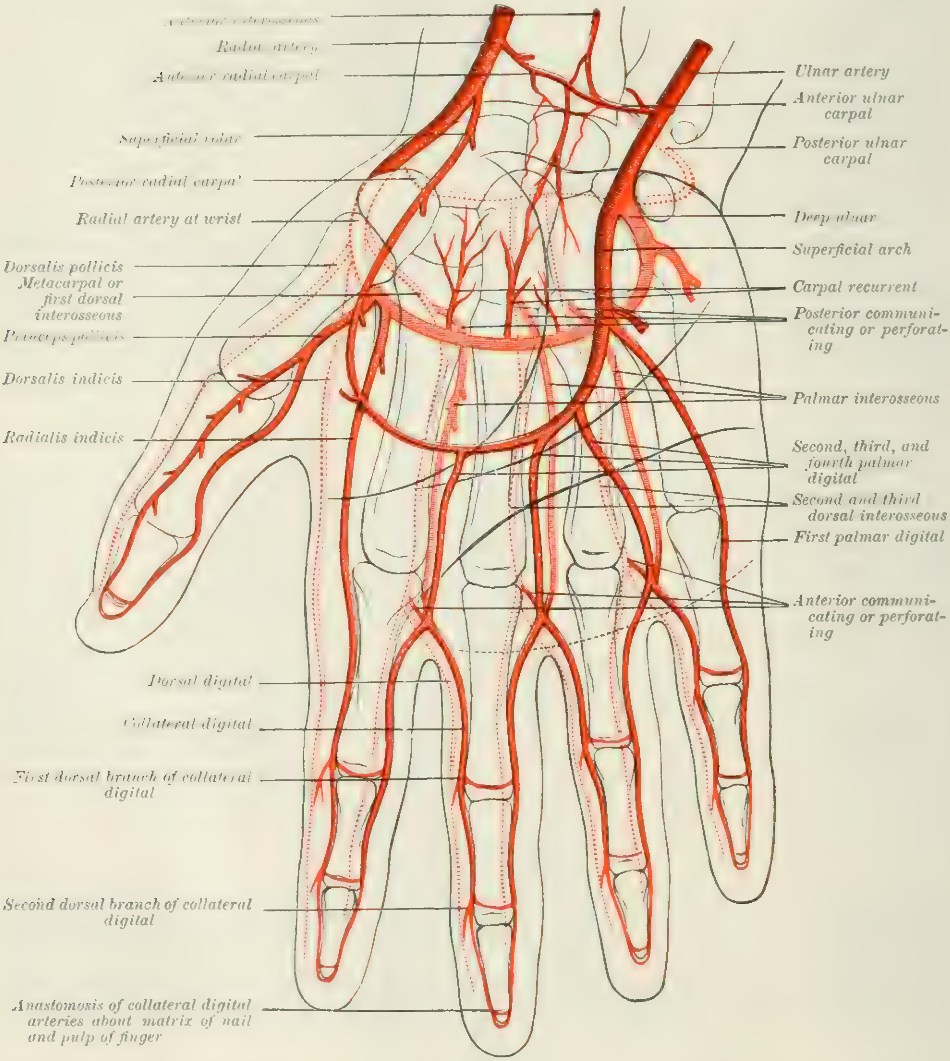
The **branches of the deep palmar arch** are:—(1) The princeps pollicis; (2) the radialis indicis; (3) the palmar interosseous (three in number); (4) the recurrent carpal; (5) the posterior perforating. The first two are usually spoken of as coming off from the radial artery in the palm; the last three from the deep palmar arch.

(1) The **princeps pollicis** arises from the radial artery as it enters the palm, between the two heads of the abductor indicis. It passes downwards between the adductor transversus pollicis and abductor indicis, parallel to the metacarpal bone, and between the two portions of the flexor brevis pollicis under cover of the flexor

longus pollicis. Opposite the metacarpo-phalangeal joint it usually divides into two branches, one of which is distributed to each side of the thumb on its palmar aspect. These vessels anastomose with each other at the end of the thumb, like the other collateral digital arteries.

(2) The **radialis indicis** comes off from the radial artery a little lower than the former vessel, or as a common trunk with it, and passes forwards between the abductor indicis and adductor transversus pollicis, parallel to the radial side of the second metacarpal bone. After emerging from beneath the adductor transversus pollicis, it continues its course along the radial side of the index finger, on its palmar aspect, as far as the tip, anastomosing in this course with the collateral digital artery on the opposite side of the finger in a way similar to that of the other collateral digital arteries. It frequently communicates, at the lower border of the adductor pollicis, with the superficial palmar arch and princeps pollicis. It gives off a dorsal branch, which anastomoses with the dorsalis indicis.

FIG. 359.—ANASTOMOSES AND DISTRIBUTION OF THE ARTERIES OF THE HAND.


Anterior interosseous
Radial artery
Anterior radial carpal
Superficial volar
Posterior radial carpal
Radial artery at wrist
Dorsalis pollicis
Metacarpal or first dorsal interosseous
Princeps pollicis
Dorsalis indicis
Radialis indicis
Dorsal digital
Collateral digital
First dorsal branch of collateral digital
Second dorsal branch of collateral digital
Anastomosis of collateral digital arteries about matrix of nail and pulp of finger
Ulnar artery
Anterior ulnar carpal
Posterior ulnar carpal
Deep ulnar
Superficial arch
Carpal recurrent
Posterior communicating or perforating
Palmar interosseous
Second, third, and fourth palmar digital
Second and third dorsal interosseous
First palmar digital
Anterior communicating or perforating

(3) The **palmar interosseous arteries,** three in number, come off from the

convexity of the deep arch, and, coursing downwards in the centre of the second, third, and fourth interosseous spaces on the interosseous muscles, terminate near the clefts of the fingers by anastomosing with the digital arteries from the superficial arch. These vessels supply the interosseous muscles and the bones, and the second, third, and fourth lumbricales.

(4) The **recurrent branches** come off from the concavity of the arch, and consist of two or three small vessels which run upwards towards the wrist, and anastomose above with the anterior branch of the anterior interosseous, and laterally with the anterior radial and ulnar carpal arteries, forming the so-called anterior carpal rete (fig. 359).

(5) The **posterior, communicating,** or **perforating,** also usually three in number, pass from the arch directly through the second, third, and fourth interosseous spaces between the two heads of the corresponding dorsal interosseous muscle, and join the proximal ends of the metacarpal artery (first dorsal interosseous), and the second and third dorsal interosseous arteries respectively.

THE DESCENDING, OR THORACIC AORTA

The **thoracic aorta** (fig. 360) extends from the termination of the aortic arch at the lower border of the body of the fifth thoracic vertebra to the lower border of the body of the twelfth thoracic vertebra, where it passes through the aortic opening in the diaphragm, and is thence continued under the name of the abdominal aorta. It is at first situated a little to the left of the vertebral column, but as it descends approaches the front of the column, at the same time following the backward curve of the spine, and at its passage through the diaphragm is almost in the middle line. It lies in the posterior mediastinum, having the œsophagus at first a little to the right of it, then in front of it, and just above the tenth thoracic vertebra, where this tube pierces the diaphragm, a little to its left side.

Relations.—In front it is crossed from above downwards by the root of the left lung, by the œsophagus, which separates it from the pericardium and heart, and by the diaphragm.

Behind, it lies upon the lower seven thoracic vertebræ, and is crossed obliquely opposite the seventh or eighth thoracic vertebra by the vena azygos minor, and opposite the fifth or sixth vertebra by the third azygos vein, or by one or more of the left intercostal veins.

On the **right side** it has, above, the œsophagus, and lower down the right pleura and lung. The vena azygos major and thoracic duct also lie to the right, but on a somewhat posterior plane.

On the **left side** it has the left lung and pleura above, and the œsophagus below. The vena azygos minor and the third azygos vein are also to the left, but on a posterior plane.

BRANCHES OF THE THORACIC AORTA

The **branches of the thoracic aorta** may be divided into the visceral and the parietal. The **visceral** are:—(1) The pericardiac; (2) the bronchial; and (3) the œsophageal. The **parietal** are:—(1) The intercostal; (2) the subcostal; (3) the diaphragmatic; and (4) the arteria aberrans.

A. *Visceral Branches*

(1) The **pericardiac**—two or three small branches, irregular in their origin, course, and distribution—pass to the posterior surface of the pericardium to supply that structure, and anastomose with the other pericardiac branches. They give small twigs to the posterior mediastinal glands.

(2) The **bronchial arteries** (fig. 324) supply the bronchi and the lung substance. They vary considerably in their origin, course, and distribution; they are usually three in number—one on the right side, and two on the left.

(*a*) The **right bronchial** generally arises either from the first right aortic intercostal, or else as a common trunk with the left upper bronchial from the front of the thoracic aorta just below the level of the bifurcation of the trachea. It passes outwards on the back of the right bronchus, and is distributed to the bronchi and lung substance. (*b*) The **left upper bronchial** arises from the front of the thoracic aorta just below the bifurcation of the trachea, or as a common trunk with the right bronchial. (*c*) The **left lower bronchial** arises from the front of the thoracic aorta just below the level of the left bronchus. Like the corresponding artery on the right side, the left bronchial arteries run outwards on the left bronchus, and, after dividing and subdividing on the back of the bronchi, supply the bronchi themselves and the lung substance. Small twigs are given off from the bronchial arteries to the **bronchial glands** and to the **œsophagus.**

FIG. 360.—THE ARCH OF THE AORTA, THE THORACIC AORTA, AND THE ABDOMINAL AORTA, WITH THE SUPERIOR AND INFERIOR VENA CAVA AND THE INNOMINATE AND AZYGOS VEINS.

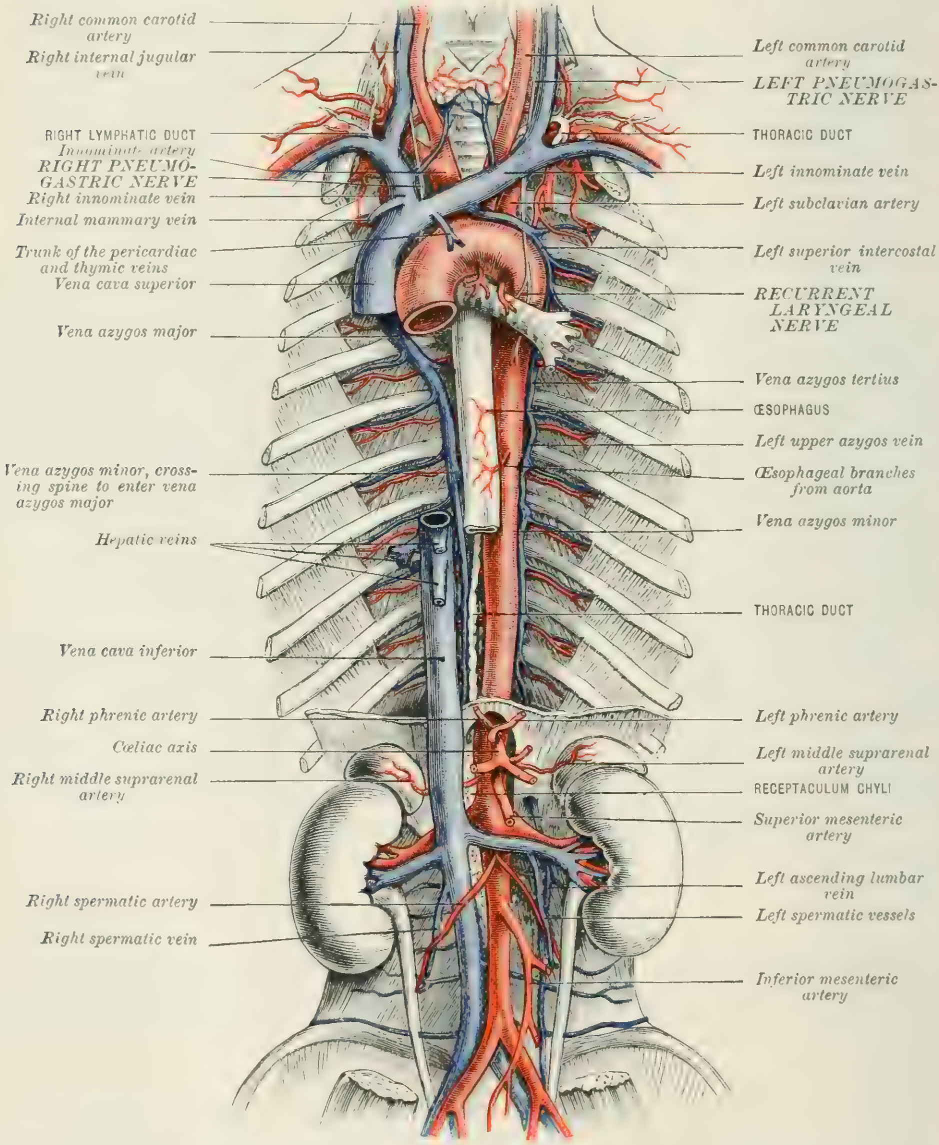
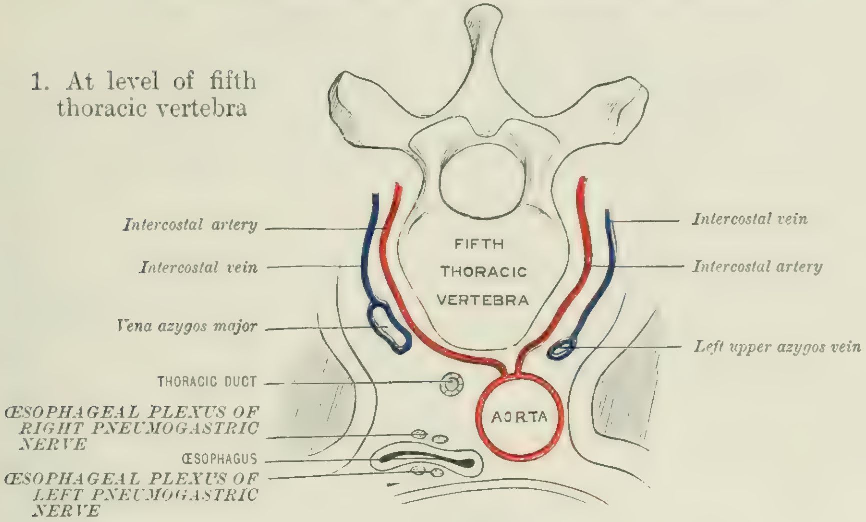
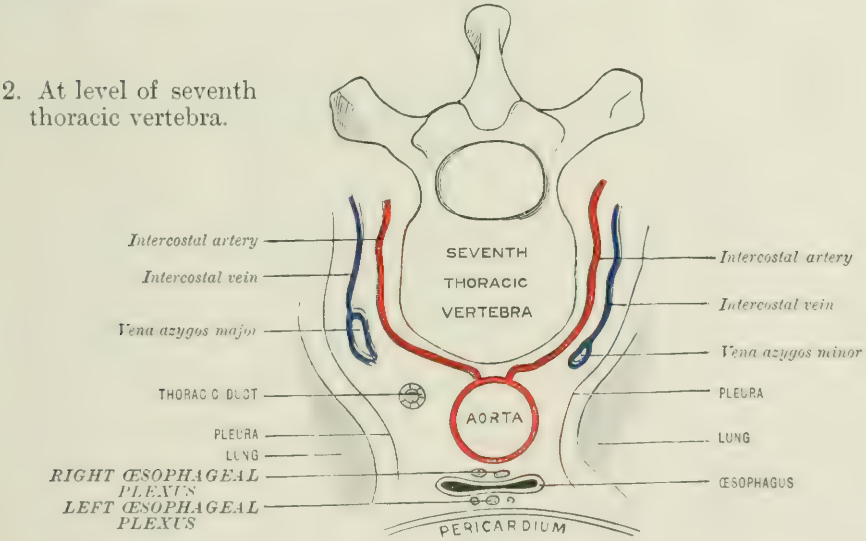

Right common carotid artery
Right internal jugular vein
RIGHT LYMPHATIC DUCT
Innominate artery
RIGHT PNEUMO-GASTRIC NERVE
Right innominate vein
Internal mammary vein
Trunk of the pericardiac and thymic veins
Vena cava superior
Vena azygos major
Vena azygos minor, crossing spine to enter vena azygos major
Hepatic veins
Vena cava inferior
Right phrenic artery
Cœliac axis
Right middle suprarenal artery
Right spermatic artery
Right spermatic vein
Left common carotid artery
LEFT PNEUMOGASTRIC NERVE
THORACIC DUCT
Left innominate vein
Left subclavian artery
Left superior intercostal vein
RECURRENT LARYNGEAL NERVE
Vena azygos tertius
ŒSOPHAGUS
Left upper azygos vein
Œsophageal branches from aorta
Vena azygos minor
THORACIC DUCT
Left phrenic artery
Left middle suprarenal artery
RECEPTACULUM CHYLI
Superior mesenteric artery
Left ascending lumbar vein
Left spermatic vessels
Inferior mesenteric artery

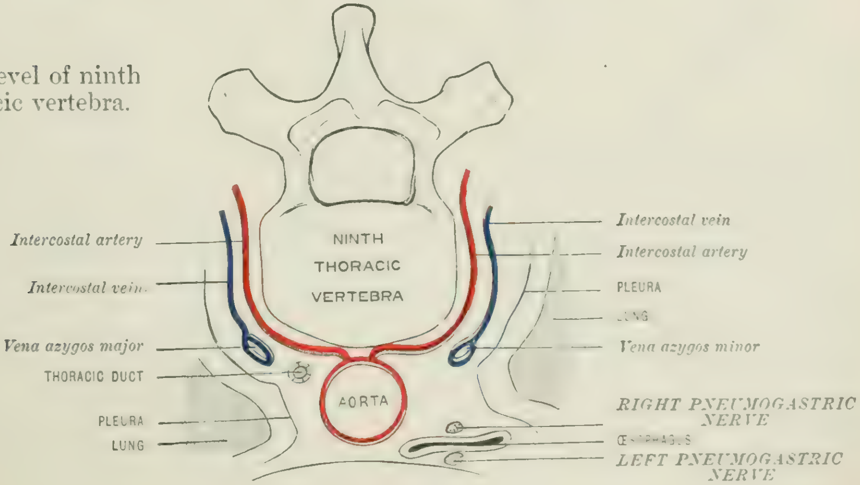
FIG. 361.—SCHEME OF THE THORACIC AORTA. (Walsham.)


1. At level of fifth thoracic vertebra

Intercostal artery
Intercostal vein
Vena azygos major
THORACIC DUCT
ŒSOPHAGEAL PLEXUS OF RIGHT PNEUMOGASTRIC NERVE
ŒSOPHAGUS
ŒSOPHAGEAL PLEXUS OF LEFT PNEUMOGASTRIC NERVE
FIFTH THORACIC VERTEBRA
AORTA
Intercostal vein
Intercostal artery
Left upper azygos vein


2. At level of seventh thoracic vertebra.

Intercostal artery
Intercostal vein
Vena azygos major
THORACIC DUCT
PLEURA
LUNG
RIGHT ŒSOPHAGEAL PLEXUS
LEFT ŒSOPHAGEAL PLEXUS
SEVENTH THORACIC VERTEBRA
AORTA
PERICARDIUM
Intercostal artery
Intercostal vein
Vena azygos minor
PLEURA
LUNG
ŒSOPHAGUS


3. At level of ninth thoracic vertebra.

Intercostal artery
Intercostal vein
Vena azygos major
THORACIC DUCT
PLEURA
LUNG
NINTH THORACIC VERTEBRA
AORTA
Intercostal vein
Intercostal artery
PLEURA
LUNG
Vena azygos minor
RIGHT PNEUMOGASTRIC NERVE
ŒSOPHAGUS
LEFT PNEUMOGASTRIC NERVE

(3) The **œsophageal arteries,** four or sometimes five in number, arise at intervals from the front of the thoracic aorta, the first coming off just below the left lower bronchial. They usually increase in size from above downwards, the upper coming off more towards the right side of the aorta, the lower more towards the left side. They pass forwards to the œsophagus, supplying that tube and anastomosing with each other and with the descending œsophageal branches of the inferior thyroid above, and with the ascending œsophageal branches of the phrenic and gastric arteries below, thus forming a chain of anastomoses along the whole length of the tube.

B. *Parietal Branches*

(1) The **aortic intercostal arteries,** usually ten in number on each side, supply the lower intercostal spaces, the two upper spaces being supplied by the superior intercostal branch of the subclavian artery. The tenth artery runs along the lower border of the last rib, and would be better called the **subcostal artery**; it is similar in its distribution to the other intercostals, but is described separately.

The aortic intercostals arise in pairs from the back part of the thoracic aorta, and at once turning, the one to the right, the other to the left, wind backwards over the front and sides of the vertebral bodies to reach the intercostal spaces, which they follow, and anastomose in front with the anterior intercostals given off from the internal mammary and musculo-phrenic arteries respectively. In fœtal life these arteries run almost transversely backwards, or even with a slight inclination downwards, to the intercostal spaces; but after the first year, in consequence of the disproportionate growth of the aorta and vertebral column, the upper intercostals have to ascend to reach their respective spaces. For convenience of description the intercostal arteries may be divided into two portions—the vertebral, which lies upon the bodies of the vertebræ; and the intercostal, which lies in the intercostal spaces.

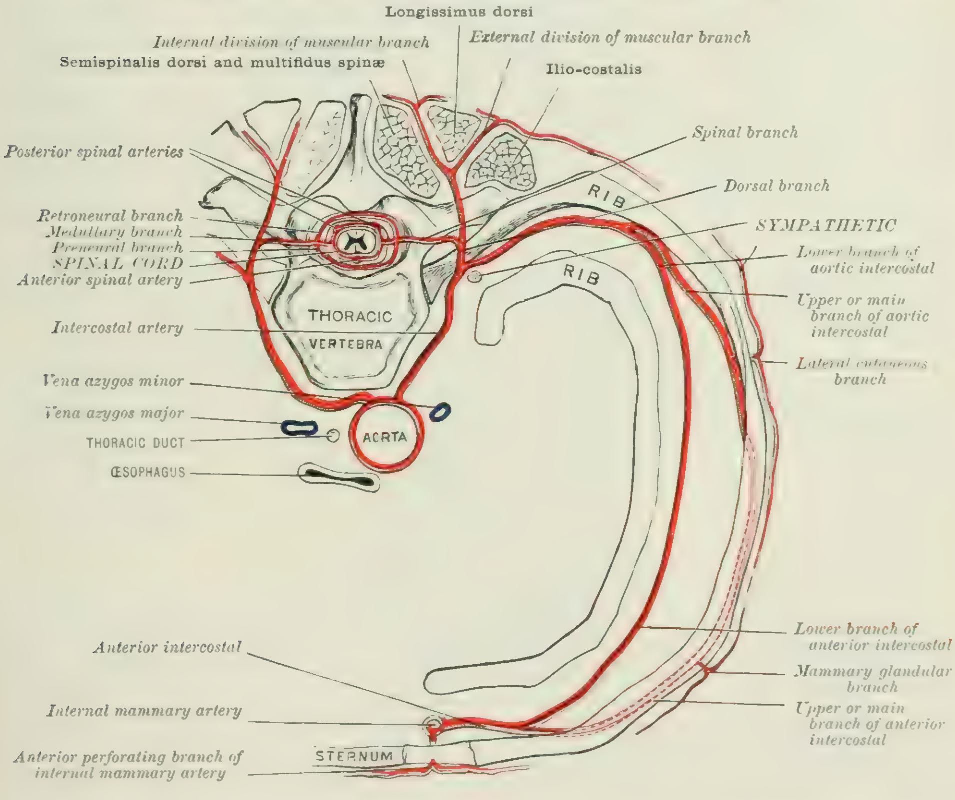
The vertebral portion.—The arteries in their course round the vertebræ differ on the two sides of the body. On the **right side** the arteries—and especially the upper, in consequence of the aorta lying a little to the left side of the spine in the upper part of its course—are longer than the left. They wind over the front and right side of the vertebræ, being crossed by the thoracic duct and vena azygos major, and covered by the right pleura and lung. The upper are also crossed by the œsophagus. They give off small branches to the bodies of the vertebræ and anterior common ligament. On the **left side,** as the intercostals wind round the sides of the bodies of the vertebræ, the lower are crossed by the vena azygos minor, the two upper by the left superior intercostal vein, and the two next by the third azygos vein when this is present. They are all covered by the left pleura and lung.

The intercostal portion.—In their course through the intercostal spaces the arteries are alike on both sides. They at first cross the intercostal spaces obliquely, in consequence of the downward direction of the ribs, towards the angle of the rib above, and thence are continued forward in the subcostal groove, and anastomose with the superior branches of the anterior intercostals from the internal mammary in the upper spaces, and from the musculo-phrenic in the lower spaces. They lie at first on the external intercostal muscles, being covered in front by the pleura and lung, the endothoracic fascia and the infra-costales muscles. Opposite the heads of the ribs they are crossed by the sympathetic nerve. At the angle of the ribs they pass under cover of the internal intercostal muscles, and thence to their termination lie between the two intercostal muscles. Their situation in the midspace as far as the angle of the rib should be remembered in performing paracentesis thoracis. To avoid the risk of injuring the vessels, the puncture should not be made further back than the angle of the ribs. They are accompanied by an intercostal nerve and vein, the vein lying above and the nerve below, except in the upper spaces where the artery, having to ascend to reach the space, at first lies below the nerve which passes transversely outwards. The uppermost aortic intercostal artery anastomoses with the superior intercostal from the subclavian, and at times supplies almost entirely the second intercostal space. The arteries to the tenth and eleventh spaces on reaching the end of their respective ribs pass between the abdominal muscles, and anastomose with the deep epigastric artery from the external iliac, and with the lumbar arteries from the abdominal aorta.

The intercostal arteries give off the following branches:—

(*a*) **The dorsal branch.**—This large branch is given off from the intercostals opposite the quadrilateral space bounded by the transverse process of the vertebra above, the neck of the rib below, the body of the vertebra internally, and the superior costo-transverse ligament externally. Passing backwards towards this space with the dorsal branch of the corresponding intercostal nerve, the dorsal branch divides opposite the intervertebral foramen into a spinal and a muscular branch. (i) The **spinal branch** enters the intervertebral foramen along with the undivided trunk of the intercostal nerve, and subdivides into three branches:—(*α*) an anterior, or preneural, which ramifies on the back of the body of the vertebra and anastomoses with the corresponding vessels above and below; (*β*) a posterior, or retroneural, which ramifies over the back of the spinal canal and also anastomoses with the like artery above and below; and (*γ*) a middle or medullary, which, passing inwards in the sheath of dura mater to the spinal cord, anastomoses with the anterior spinal artery in front, and with the posterior spinal artery behind. (ii) The **muscular branch** passes backwards through the quadrilateral space, and soon subdivides into an external and internal branch. The former passes between the longissimus dorsi and ilio-costalis, and, after supplying these muscles, gives cutaneous offsets to the integuments. The latter or internal branch pierces the multifidus spinæ, and, emerging between the longissimus dorsi and semispinalis dorsi near the spinous processes, gives cutaneous offsets to the skin. It supplies the muscles in its course.

FIG. 362.—SCHEME OF INTERCOSTAL ARTERY. (Walsham.)


Longissimus dorsi
Internal division of muscular branch
External division of muscular branch
Semispinalis dorsi and multifidus spinæ
Ilio-costalis
Spinal branch
Posterior spinal arteries
Dorsal branch
RIB
SYMPATHETIC
Retroneural branch
Medullary branch
Preneural branch
SPINAL CORD
Anterior spinal artery
Lower branch of aortic intercostal
RIB
Upper or main branch of aortic intercostal
THORACIC
Intercostal artery
VERTEBRA
Lateral cutaneous branch
Vena azygos minor
Vena azygos major
THORACIC DUCT
AORTA
ŒSOPHAGUS
Lower branch of anterior intercostal
Anterior intercostal
Mammary glandular branch
Internal mammary artery
Upper or main branch of anterior intercostal
Anterior perforating branch of internal mammary artery
STERNUM

(*b*) The **collateral intercostal branch** comes off from the intercostal artery near the angle of the rib above, and descends to the upper border of the rib below, along which it runs between the intercostal muscles to anastomose with the inferior division of the anterior intercostal branch of the internal mammary artery. It is much smaller than the main intercostal artery, and helps to supply the structures in the intercostal space and neighbouring parts.

(*c*) The **pleural branches** ramify beneath the pleura, forming a plexus by anastomosing with like branches above and below.

(*d*) The **muscular branches** supply the intercostals, serratus magnus, and pectoralis major and minor, and anastomose with the long and short thoracic branches of the axillary artery.

(*e*) The **lateral cutaneous branches** run with the lateral cutaneous branches of the intercostal nerves to the skin.

(*f*) The **mammary glandular branches** are given off from the intercostal arteries in the third, fourth, and fifth intercostal spaces, and supply the mammary gland. They are of large size during lactation, and generally require a ligature in the removal of the breast.

(2) The **subcostal artery,** or the **twelfth dorsal** as it is sometimes called, follows the same course as the intercostals as far as the head of the twelfth rib. It then passes in company with the twelfth dorsal nerve along the lower border of the twelfth rib, lying in front of the quadratus lumborum muscle, behind the fascia transversalis. Crossing in front of it is the thickened upper bridge-like margin of this fascia, which stretches across the quadratus and gives origin to some of the fibres of the diaphragm, and is known as the ligamentum arcuatum externum. The subcostal artery anastomoses with the lumbar arteries and external circumflex iliac artery. At the outer edge of the quadratus lumborum it passes between the abdominal muscles, and is distributed in a manner similar to that of the lumbar arteries.

(3) The **diaphragmatic branches** are small twigs coming off from the thoracic aorta immediately above the diaphragm. They are distributed to the vertebral portion of the diaphragm on its upper surface.

(4) The **aberrans artery** is a small twig which, arising from the thoracic aorta near the right bronchial artery, passes upwards and to the right behind the œsophagus and trachea, and is occasionally found to anastomose on the œsophagus with the arteria aberrans of the superior intercostal artery. It is regarded as the remains of the right aortic dorsal stem (fig. 345).

THE ABDOMINAL AORTA

The **abdominal aorta** (fig. 363), the continuation of the descending or thoracic aorta, begins at the aortic opening in the diaphragm opposite the lower border of the twelfth thoracic vertebra, and ends opposite the middle of the body of the fourth lumbar vertebra on its left side, by dividing into the right and left common iliac arteries. It is at first centrally placed between the pillars of the diaphragm, but as it descends in front of the lumbar vertebræ it leaves the middle line, and, at its bifurcation, lies a little to the left side of the spine. The spot at which the aorta bifurcates is, for all practical purposes, roughly indicated on the surface of the abdomen by a point about half an inch below and a little to the left of the umbilicus. But the level of its bifurcation may be more accurately determined by a line drawn across the front of the abdomen from the highest point of one iliac crest to the highest point of the other.

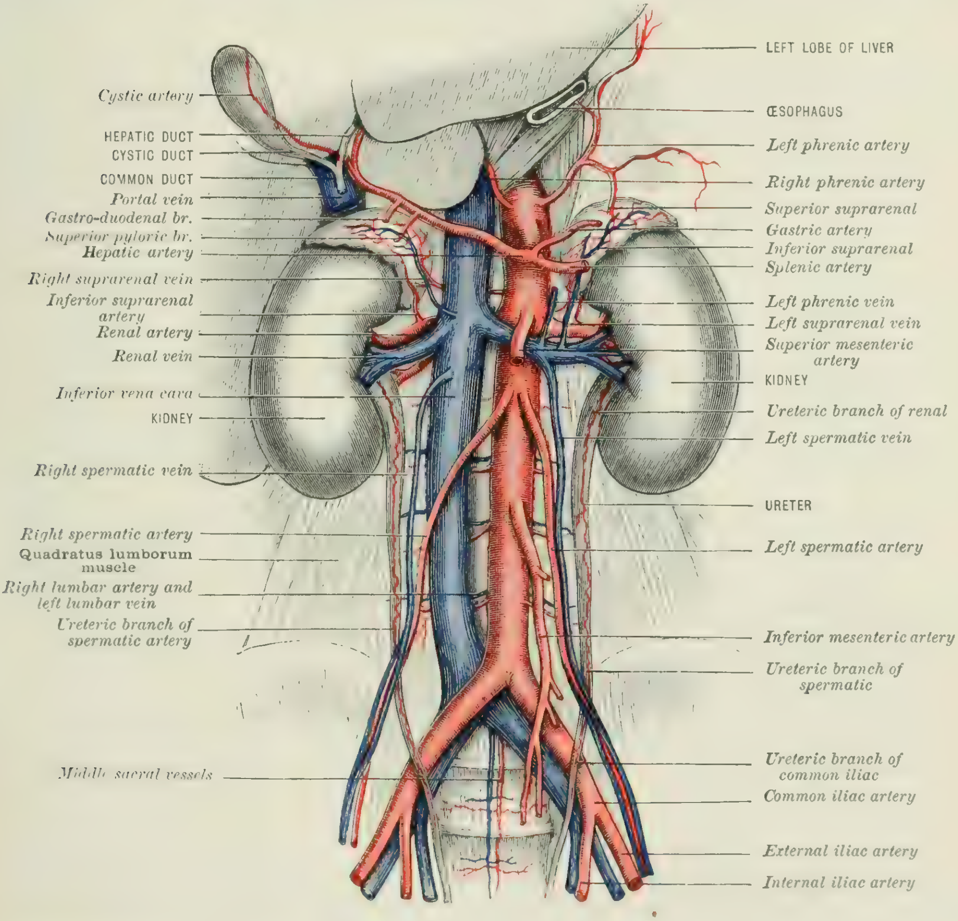
The vena cava inferior, which accompanies the abdominal aorta, lies to its right side. Below, the vein is in contact with the artery and on a somewhat posterior plane; but above, it is separated from the aorta by the right crus of the diaphragm, and in consequence of the caval opening in the diaphragm being placed further forward than the opening for the aorta, is on an anterior plane.

Relations.—In front (fig. 364), the aorta is successively crossed from above downwards by the right lobe of the liver, the solar plexus, the lesser omentum, the termination of the œsophagus in the stomach, the ascending layer of the transverse meso-colon, the splenic vein or commencement of the vena porta, the pancreas, the left renal vein, the third portion of the duodenum, the mesentery, the aortic plexus of the sympathetic nerve, the spermatic or ovarian arteries, the inferior mesenteric artery, the median lumbar lymphatic glands and lymphatic vessels, and the small intestines.

Of these structures the solar plexus, the aortic plexus, the splenic vein or the commencement of the vena porta, the pancreas, the left renal vein, the duodenum, the lymphatics, the spermatic or ovarian arteries, and the peritoneal reflexions are in contact with the aorta.

Behind, the aorta lies upon the bodies of the lumbar vertebræ and intervening intervertebral cartilages, the anterior common ligament, the origin of the left crus of the diaphragm, and the left lumbar veins.

FIG. 363.—THE ABDOMINAL AORTA AND ITS BRANCHES, WITH THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.


Cystic artery
HEPATIC DUCT
CYSTIC DUCT
COMMON DUCT
Portal vein
Gastro-duodenal br.
Superior pyloric br.
Hepatic artery
Right suprarenal vein
Inferior suprarenal artery
Renal artery
Renal vein
Inferior vena cava
KIDNEY
Right spermatic vein
Right spermatic artery
Quadratus lumborum muscle
Right lumbar artery and left lumbar vein
Ureteric branch of spermatic artery
Middle sacral vessels
LEFT LOBE OF LIVER
ŒSOPHAGUS
Left phrenic artery
Right phrenic artery
Superior suprarenal
Gastric artery
Inferior suprarenal
Splenic artery
Left phrenic vein
Left suprarenal vein
Superior mesenteric artery
KIDNEY
Ureteric branch of renal
Left spermatic vein
URETER
Left spermatic artery
Inferior mesenteric artery
Ureteric branch of spermatic
Ureteric branch of common iliac
Common iliac artery
External iliac artery
Internal iliac artery

On the **right side** from above downwards are the right crus of the diaphragm, the great splanchnic nerve, the Spigelian lobe of the liver, the receptaculum chyli and beginning of the thoracic duct (the two latter structures are on a posterior plane), the right semilunar ganglion, and the vena cava inferior.

On the **left side** are the left crus of the diaphragm, the left splanchnic nerve, and the left semilunar ganglion. The pancreas is also in contact with the aorta on the left side, as are, too, the small intestines, but separated from it by peritoneum.

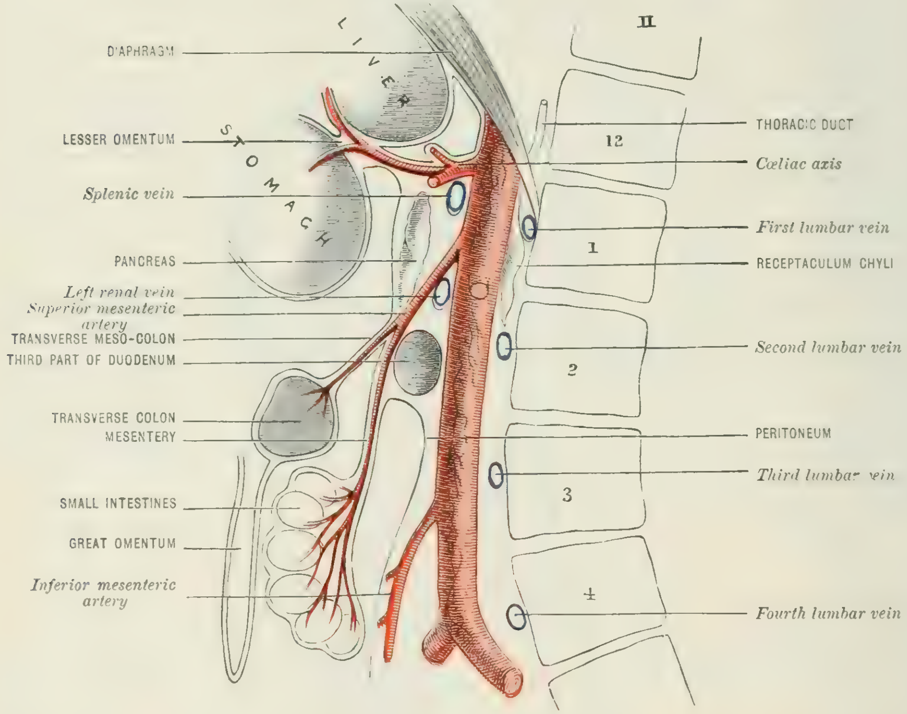
Variations in the Abdominal Aorta

Variations in the abdominal aorta, except as regards its place of division and some irregularity in the origin and number of its branches, are not common. According to Quain, in ten out of every thirteen subjects examined, the bifurcation took place within half an inch above or below the level of the highest part of the crest of the ilium. The commonest situation for its bifurcation with reference to the vertebræ is perhaps opposite the lower border of the body of the fourth lumbar, but it may divide opposite the disc between the fourth and fifth lumbar, or rarely opposite the fifth lumbar. A higher division than at the usual spot is less common. The artery, however, has been found in exceptional instances dividing as high as the origin of the renal arteries, or even as high as the second lumbar vertebra.

The following rare variations have been met with:—(A) The aorta passing through the œsophageal opening in the diaphragm. (B) The aorta lying on the right side of the vena cava; the vein then passes over the upper part of the aorta to gain the caval opening. (C) The aorta with a vena cava on each side, the left vein passing across the upper part of the artery to open into the right vein just below the caval opening. (D) The aorta giving off a pulmonary branch close to the origin of the cœliac axis, the abnormal vessel then passing through the œsophageal opening, and supplying a branch to the lower lobe of each lung.

The variations in the branches of the aorta are described under each branch.

FIG. 364.—SCHEME OF THE ABDOMINAL AORTA. (Walsham.)


DIAPHRAGM
LESSER OMENTUM
Splenic vein
PANCREAS
Left renal vein
Superior mesenteric artery
TRANSVERSE MESO-COLON
THIRD PART OF DUODENUM
TRANSVERSE COLON
MESENTERY
SMALL INTESTINES
GREAT OMENTUM
Inferior mesenteric artery
LIVER
STOMACH
II
12
1
2
3
4
THORACIC DUCT
Cœliac axis
First lumbar vein
RECEPTACULUM CHYLI
Second lumbar vein
PERITONEUM
Third lumbar vein
Fourth lumbar vein

BRANCHES OF THE ABDOMINAL AORTA

The **branches of the abdominal aorta** are given off in the following order from above downwards (fig. 363):—

(1) Right and left phrenic; (2) cœliac axis; (3) right and left suprarenal or capsular; (4) right and left first lumbar; (5) superior mesenteric; (6) right and left renal; (7) right and left spermatic; (8) right and left second lumbar; (9) inferior mesenteric; (10) right and left third lumbar; (11) right and left fourth lumbar; (12) right and left common iliac; (13) middle sacral.

The above branches may be divided into the parietal, the visceral, and the terminal.

The **parietal branches** are distributed to the abdominal walls. They are the right and left phrenics, and the four right and left lumbars.

The **visceral branches** supply the viscera. Three of these are given off singly from the front of the aorta, namely, the cœliac axis, the superior mesenteric and the inferior mesenteric; and three are given off in pairs, namely, the two suprarenals, the two renals, and the two spermatics.

The **terminal branches** are the middle sacral and the right and left common iliac arteries.

A. The Parietal Branches of the Abdominal Aorta

1. THE PHRENIC ARTERIES

The **right** and **left phrenic arteries**—sometimes called the **inferior phrenic** to distinguish them from the diaphragmatic branches of the internal mammary and thoracic aorta—usually arise from the aorta as it passes between the crura of the diaphragm either as a common trunk or as separate vessels. At times they come off as a common trunk from the cœliac axis; or either the right or left vessel may come from this artery, or from other of the upper branches of the abdominal aorta.

The **right phrenic** passes (fig. 363) over the right crus of the diaphragm behind the vena cava, and then upwards and to the right between the central and right leaflets of the central tendon of the muscle, where it divides into an **anterior** and a **posterior** branch. The former courses forwards and inwards, and anastomoses with the anterior branch of the left phrenic, with the musculo-phrenic branches of the internal mammary, and with the superior phrenic arteries; the latter passes outwards and backwards towards the ribs, and anastomoses with the intercostal arteries. Besides the two terminal branches and branches for the supply of the diaphragm itself, the right phrenic gives off the following:—(1) **Right superior suprarenal,** to the right suprarenal capsule; (2) **caval,** to the vena cava; (3) **hepatic,** to the liver; and (4) **pericardiac,** to the pericardium.

The **left phrenic** crosses the left crus of the diaphragm behind the œsophagus, and then runs between the left and central leaflets of the tendon, dividing like the right into an **anterior** and a **posterior** branch. The former runs forwards and inwards, and anastomoses with the anterior branch of the right phrenic, the left musculo-phrenic from the internal mammary, and the superior phrenic artery. The latter courses outwards and backwards towards the ribs, and anastomoses with the intercostal arteries. In addition to the terminal branches, and branches to the diaphragm itself, the left phrenic gives off:—(1) **Œsophageal branches** to the œsophagus, where they anastomose with the other œsophageal branches; (2) **left superior suprarenal,** to the left suprarenal body; (3) **splenic,** to the spleen; and (4) **pericardiac,** which perforate the diaphragm and anastomose with the other pericardiac arteries.

The **variations** in the origin of the phrenic arteries are very numerous. The chief have been alluded to in the general description of the vessels.

2. THE LUMBAR ARTERIES

The **lumbar arteries** (figs. 360, 363), usually eight in number, four on each side, come off in pairs from the posterior aspect of the abdominal aorta, opposite the bodies of the four upper lumbar vertebræ. A fifth pair of lumbar arteries, generally of small size, are frequently given off from the middle sacral opposite the fifth lumbar vertebra. The lumbar arteries, which are rather longer on the right than on the left side, in consequence of the aorta lying a little to the left of the median line, wind more or less transversely outwards round the bodies of the vertebræ to the interval between the transverse processes, where they give off a dorsal branch, and then, coursing forwards between the abdominal muscles, terminate by anastomosing with the other arteries of the abdominal wall. As they wind round the bodies of the vertebræ they pass beneath the chain of the sympathetic nerve, and the upper two beneath the right crus of the diaphragm on the right side, and the left crus on the left side. The right arteries also pass beneath the vena cava inferior, and the two upper on that side beneath the receptaculum chyli. The arteries on both sides then dip beneath the tendinous arch thrown across the sides of the bodies of the vertebræ by the psoas, and continue beneath this muscle until they arrive at the interval between the transverse processes of the vertebræ and the inner edge of the quadratus lumborum. Whilst under cover of the psoas they are accompanied by two slender filaments of the sympathetic nerve and by the lumbar veins. A little anterior to the transverse processes they are crossed by branches of the lumbar plexus, and here usually cross in front of the ascending lumbar vein. They now pass behind the quadratus lumborum, with the exception usually of the first, and sometimes of the last, which may pass in front of the muscle. At the outer edge of the quadratus they run between the transversalis and the internal oblique, and then, perforating the internal oblique, between the internal and external oblique. Finally, much diminished in size, they enter the rectus, and give off one or more anterior cutaneous branches, which accompany the last dorsal and the ilio-hypogastric nerves to the skin. They anastomose with the lower intercostals, ilio-lumbar, deep circumflex iliac, and deep epigastric arteries.

The lumbar arteries give off the following branches:—

(*a*) **Vertebral branches** which supply the bodies of the vertebræ and their connecting ligaments.

(*b*) **Muscular branches** to the psoas, quadratus lumborum, and oblique muscles of the abdomen.

(*c*) The **dorsal branch.** This is of large size, and passes backwards in company with the dorsal nerve between the transverse processes above and below, the intertransversalis internally, and the quadratus lumborum externally, to the muscles of the back. On reaching the interval between the longissimus dorsi and multifidus spinæ, it divides into an external and internal branch. The former ends in the multifidus, the latter and larger supplies the erector spinæ, and gives branches which accompany the termination of the dorsal nerves to the skin. Just before the artery passes between the transverse processes it gives off a spinal branch, which accompanies the lumbar nerve through the intervertebral foramen into the spinal canal. Here the spinal branch divides into three twigs, one of which passes through the sheath of the dura mater to the termination of the spinal cord and cauda equina; the other two are distributed to the walls of the spinal canal after the way described in the case of the intercostals.

(*d*) **Renal branches** of small size pass forwards in front of the quadratus lumborum to the capsule of the kidney. They anastomose with the renal artery. A communication is thus established between the renal arteries and the arteries supplying the lumbar region.

The **fifth pair of lumbar arteries,** when present, usually come off from the middle sacral artery. Each courses outwards, beneath the common iliac artery and vein; and, after giving off a dorsal branch, ramifies over the lateral mass of the sacrum, and ends in the iliacus muscle by anastomosing with the circumflex iliac artery. The **dorsal branch** passes to the back between the last lumbar vertebra and the sacrum and ramifies in the gluteus maximus, anastomosing with the lumbar arteries above, and with the gluteal artery below.

The **variations** in the lumbar arteries are not of great importance. (A) One or more pairs may arise as a common stem from the back of the aorta. (B) The first lumbar may be joined at its origin with the subcostal artery; or the third and fourth lumbar, or less often the second and third lumbar, may arise from the aorta as a common stem. (C) The fifth pair may sometimes be absent. (D) The first lumbar may give off the phrenic or the suprarenal. (E) One of the lumbar arteries may give off the spermatic. (F) The fourth lumbar on either side may give off the middle sacral, or both arteries may arise as a common stem with the middle sacral.

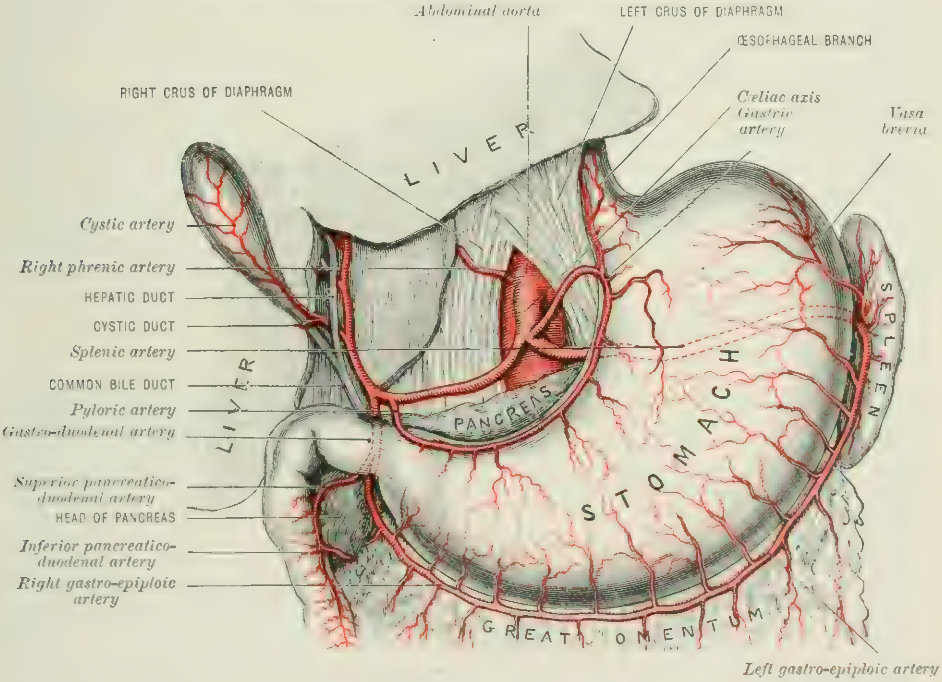
B. The Visceral Branches of the Abdominal Aorta

THE CŒLIAC ARTERY

The **cœliac artery**—or **cœliac axis** as it is commonly called, because it breaks up simultaneously into three branches which radiate from it like the spokes of a wheel from the axle—is a short thick trunk given off from the front of the aorta between the crura of the diaphragm a little below the aortic opening. It passes horizontally forwards above the upper margin of the pancreas for about half an inch, and then breaks up into three branches for the supply of the stomach, duodenum, spleen, pancreas, liver, and gall-bladder (fig. 365).

Relations.—In front is the lesser omentum; **behind,** the aorta; **above,** the right lobe of the liver; **below,** the pancreas; to the **right,** the right semilunar ganglion and lobulus Spigelii of the liver; to the **left,** the left semilunar ganglion and the cardiac end of the stomach. It is closely surrounded by the dense solar plexus of sympathetic nerves.

Fig. 365.—The Cœliac Artery and its Branches.



Abdominal aorta
LEFT CRUS OF DIAPHRAGM
ŒSOPHAGEAL BRANCH
RIGHT CRUS OF DIAPHRAGM
Cœliac axis
Gastric artery
Vasa brevia
LIVER
Cystic artery
Right phrenic artery
HEPATIC DUCT
CYSTIC DUCT
Splenic artery
COMMON BILE DUCT
Pyloric artery
Gastro-duodenal artery
LIVER
Superior pancreatico-duodenal artery
HEAD OF PANCREAS
Inferior pancreatico-duodenal artery
Right gastro-epiploic artery
PANCREAS
STOMACH
SPLEEN
GREAT OMENTUM
Left gastro-epiploic artery

Variations.—(A) The cœliac axis may be absent; the branches usually arising from it then coming off separately from the aorta. (B) It may be shorter or longer than usual. Under the latter circumstance the branches are commonly given off separately from the trunk of the vessel instead of radiating from one spot. (C) It may give off two branches only: these are usually the splenic and hepatic, more rarely the gastric and the splenic. (D) It may give off more than three branches, the additional branch being one of the phrenics; a trunk common to the two phrenics; a gastro-duodenal; a second gastric or splenic artery, or the superior mesenteric; the median colic or the pancreatica magna. (E) One or other of the branches normal to the cœliac axis may be absent, or replaced by a stem common to the phrenics, or by the right suprarenal and the right gastro-epiploic, or more rarely by some other branch.

Branches of the cœliac artery.—The cœliac axis gives off the gastric, hepatic, and splenic arteries.

1. The Gastric Artery

The **gastric** or **coronary artery** (fig. 365), the smallest of the three branches into which the cœliac axis divides, courses at first upwards and to the left towards the cardiac end of the stomach, where it turns sharply round, and then, coasting along the lesser curvature of the stomach, descends from left to right towards the pylorus. It anastomoses with the superior pyloric branch of the hepatic artery, which has proceeded from the opposite direction, the two branches thus forming a continuous arterial arch corresponding to the lesser curvature of the stomach. The artery at first lies behind the posterior layer of the lesser omental sac of peritoneum (fig. 364), but on reaching the cardiac end of the stomach it passes through the so-called pancreatico-gastric fold of peritoneum into the lesser omentum, between which it then runs to its terminal anastomosis with the pyloric. It is surrounded by the coronary plexus of sympathetic nerves.

The **branches of the gastric artery** are:—(1) The œsophageal; (2) the cardiac; (3) the gastric; and (4) the hepatic.

(1) The **œsophageal branches,** given off where the artery makes its bend on to the stomach, ascend on the œsophagus, and, passing through the œsophageal opening of the diaphragm, anastomose with the thoracic œsophageal branches and the branches from the left phrenic.

(2) The **cardiac branches,** two or more in number, are given off for the supply of the cardiac end of the stomach, around which they form an anastomotic circle.

(3) The **gastric branches** come off from the artery as it lies between the layers of the lesser omentum, and are distributed to the front and back of the stomach (the **lesser anterior** and **posterior gastric branches**), over which they ramify, anastomosing with branches ascending from the right and left gastro-epiploic on the greater curvature. One of these branches of larger size ramifies over the front of the great *cul-de-sac*, the **greater anterior gastric** (Macalister), and anastomoses with the vasa brevia and left gastro-epiploic from the splenic.

(4) The **hepatic branch** is a constant small twig passing to the left lobe of the liver, where it anastomoses with the left hepatic artery.

Chief variations.—(A) The gastric may arise directly from the aorta, and may then give off one of the phrenics, or both, or a trunk common to the two. (B) There may be two gastric arteries instead of one. (C) The gastric may give off the left branch of the hepatic artery. This appears to be due to the enlargement of the constantly present small hepatic branch, and the obliteration of part of the normal left branch of the hepatic artery.

2. The Hepatic Artery

The **hepatic artery,** the largest branch of the cœliac axis in the fœtus, but intermediate in the adult between the gastric and the splenic, comes off on the right side of the cœliac axis, and, winding upwards and to the right to the transverse or portal fissure of the liver, there breaks up into two chief branches for the supply of the right and left lobe of that organ. It at first courses forwards and to the right along the upper border of the head of the pancreas, behind the posterior layer of the lesser omental sac of peritoneum, to the upper margin of the duodenum, where, at the base of the so-called right pancreatico-gastric fold, it passes between the two layers of the lesser omentum, and thus ascends along with the hepatic duct which lies to its right, and with the portal vein which lies behind it, to the transverse or portal fissure of the liver. As it lies with the hepatic duct and portal vein between the layers of the lesser omentum, it is in front of the so-called foramen of Winslow.

The **branches of the hepatic artery** are:—(1) The pancreatic; (2) the superior pyloric; (3) the gastro-duodenal; (4) the right terminal; and (5) the left terminal.

(1) The **pancreatic,** or **lesser pancreatic branches** as they are often called, come off from the hepatic as it runs along the upper margin of the pancreas, and supply that organ.

(2) The **superior pyloric** comes off from the hepatic just as the latter vessel enters the lesser omentum, and, descending between the two layers of that fold of peritoneum to the pylorus, there turns leftwards, and, ascending from right to left,

anastomoses along the lesser curvature of the stomach, as already mentioned, with the gastric artery, which descends from the opposite direction.

(3) The **gastro-duodenal** arises from the hepatic a little beyond the pyloric. It descends behind the ascending portion of the duodenum to the lower border of the pylorus, where it divides into the **right gastro-epiploic** and the **superior pancreatico-duodenal.** It varies from half an inch to an inch in length. In addition to the above branches, it may give off the **inferior pyloric artery.**

(*a*) The **right gastro-epiploic,** entering the anterior fold of the great omentum, coasts from right to left along the greater curvature of the stomach, and anastomoses with the **left gastro-epiploic branch** of the splenic, which descends from left to right also along the greater curvature to meet it. From this anastomotic arch are given off:—(i) **Ascending** or **gastric branches,** which supply the anterior and posterior surfaces of the stomach, and anastomose with the descending gastric branches of the arteries along the lesser curvature. (ii) **Epiploic** or **omental branches**—long slender vessels, which descend between the two anterior layers of the great omentum, and then, looping upwards, anastomose with similar slender branches given off from the middle and left colic, and passing down in like manner between the two posterior layers of the great omentum.

(*b*) The **superior pancreatico-duodenal**—the smaller division of the gastro-duodenal—arises from that vessel as it passes behind the first portion of the duodenum, and courses downwards behind the peritoneum, in the anterior groove between the second portion of the duodenum and the pancreas, to anastomose with the inferior pancreatico-duodenal, a branch of the superior mesenteric, which runs upwards between the contiguous borders of the pancreas and duodenum. Both the inferior and superior pancreatico-duodenal give off branches to the duodenum and the pancreas.

(*c*) The **inferior pyloric** arises either from the gastro-duodenal or from the right gastro-epiploic; it supplies the pyloric end of the stomach, and anastomoses with the other arteries in that situation.

(4) The **right terminal branch** of the hepatic artery is given off at the portal fissure of the liver, and runs to the right towards the end of that fissure, either behind the hepatic and cystic ducts, or between these structures. At the right end of the portal fissure it divides into two or more branches, which again subdivide as they enter the liver substance for the supply of the right lobe. As it crosses the cystic duct it gives off the cystic artery.

(*a*) The **cystic artery** courses forwards and downwards through the angle formed by the union of the hepatic and cystic ducts, and just before it reaches the gall-bladder divides into a superficial and deep branch. The former breaks up into a number of small vessels, which ramify over the free surface of the gall-bladder beneath the peritoneal covering, and furnish branches to the muscular and mucous coats. The deep branch ramifies between the gall-bladder and the liver-substance, supplying each, and anastomosing with the superficial branch.

(5) The **left terminal branch,** the smaller division of the hepatic artery, runs inwards towards the left end of the portal fissure, and, after giving off a distinct branch to the Spigelian lobe, enters the left lobe of the liver.

Chief variations.—(A) The hepatic artery may arise directly from the aorta, or from the gastric, the superior mesenteric, or the right renal artery. (B) Together with a normal artery there may be an accessory hepatic from one or other of the above-named or neighbouring branches. (C) The hepatic artery may be altogether wanting, and its place supplied by one or more accessory arteries derived from one or other of the above named sources. This variation is explained by Hyrtl on the supposition that there has been obliteration of the normal hepatic, with enlargement of one or more of the minute branches which normally proceed from the aorta and the above-named branches to the capsule of the liver.

3. THE SPLENIC ARTERY

The **splenic artery**—the largest branch of the cœliac axis—arises from the left side of the termination of that vessel below the gastric, and passes along the upper border of the pancreas in a tortuous manner to the spleen. It at first lies behind the ascending layer of the transverse meso-colon, but on nearing the spleen enters the lieno-renal ligament, and there breaks up into numerous branches, which enter the hilum and supply the organ. In this course it crosses in front of the left crus of the diaphragm and the upper end of the left kidney and is placed above the splenic vein.

The **branches of the splenic artery** are:—(1) The smaller pancreatic; (2) the larger pancreatic; (3) the left gastro-epiploica; (4) the vasa brevia; and (5) the terminal.

(1) The **smaller pancreatic branches** come off from the splenic at varying intervals, as that vessel courses along the upper margin of the pancreas. They enter and supply the organ.

(2) The **larger pancreatic branch** usually arises from the splenic about the junction of its middle with its left third. Entering the pancreas obliquely, it runs from left to right, commonly above, and a little behind, the pancreatic duct, which it supplies together with the substance of the organ.

(3) The **left gastro-epiploic** arises from the splenic behind the great *cul-de-sac* of the stomach, and, passing between the anterior layers of the great omentum, descends along the greater curvature of the stomach from left to right, and anastomoses with the right gastro-epiploic. Like that vessel, it gives off **ascending** or **gastric branches** to the anterior and posterior surfaces of the stomach respectively, and long slender **descending epiploic** or **omental branches** to the great omentum which anastomose with like branches from the right and left colic arteries.

(4) The **vasa brevia** come off from the splenic just before it divides into its terminal branches, oftentimes from some of these terminal branches themselves. Passing from between the folds of the lieno-renal ligament into those of the gastro-splenic, they thus reach the greater *cul-de-sac* of the stomach, where, ramifying over both its anterior and posterior surfaces, they anastomose with the gastric and left gastro-epiploica arteries.

(5) The **terminal branches,** five to eight or more in number, are given off from the splenic as it lies in the lieno-renal ligament, and, entering the spleen at the hilum, are distributed in the way mentioned in the description of that organ.

The **variations of the splenic artery** are neither numerous nor important. (A) It may divide into two branches which reunite, the splenic vein running through the loop thus formed. (B) It may sometimes give off branches normally derived from other vessels, such as the gastric, the middle colic, and the left hepatic. (C) The variations in its origin are mentioned under VARIATIONS OF THE CŒLIAC AXIS (page 555).

THE SUPERIOR MESENTERIC ARTERY

The **superior mesenteric artery** is given off from the front of the aorta a little below the cœliac axis, which it nearly equals in size; sometimes as a common trunk with the axis. Lying at first behind the pancreas and splenic vein, it soon passes forwards between the lower border of that gland and the upper border of the third portion of the duodenum, and, crossing in front of the duodenum, enters the mesentery, in which it runs from left to right, in the form of a curve with its convexity to the left, to the cæcum, where it anastomoses with its ileo-colic branch. Its vein lies to its right side above, having previously crossed obliquely in front of the artery from left to right. It is surrounded by the mesenteric plexus of nerves. The accessory portion of the head of the pancreas dips in behind the vessel.

From the concave side of the artery branches are given off to the duodenum and the colon, viz.:—

(1) The inferior pancreatico-duodenal; (2) the middle colic; (3) the right colic; and (4) the ileo-colic.

From the convex side branches are given off to the small intestines, viz.:—

(5) The vasa intestini tenuis.

It will thus be seen that the superior mesenteric artery supplies, with the exception of the upper third of the duodenum, the whole of the small intestine and half the large.

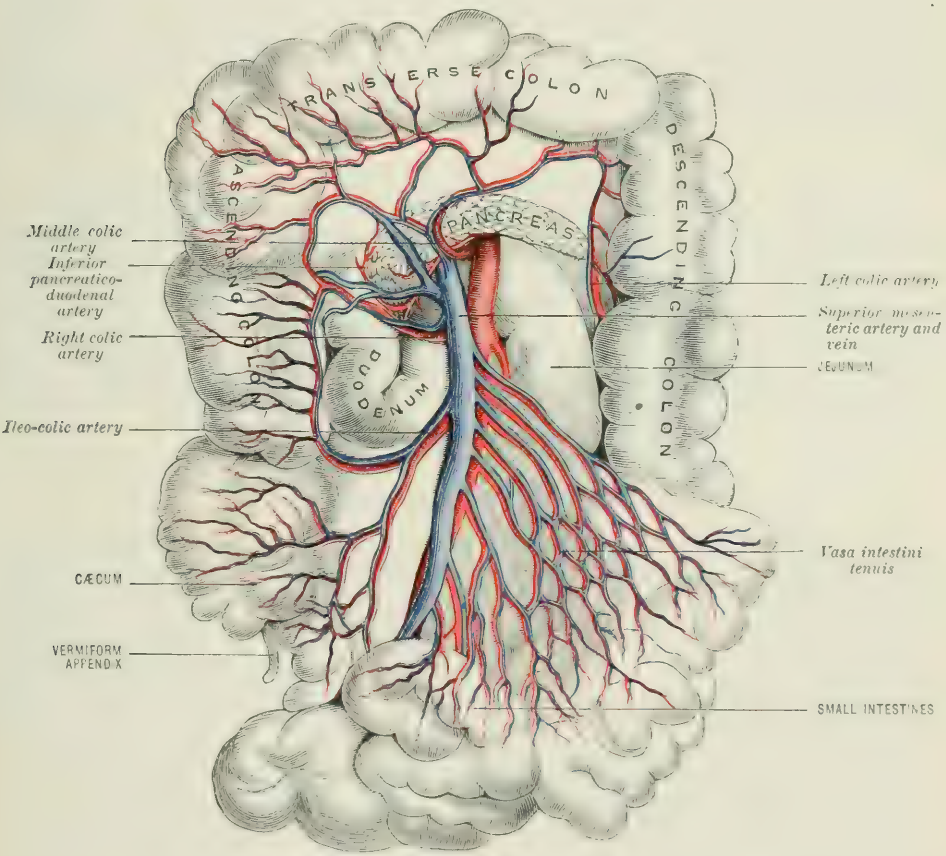
(1) The **inferior pancreatico-duodenal** arises either from the superior mesen-

teric as that vessel emerges from the contiguous margins of the pancreas and transverse duodenum or from its first intestinal branch, and, crossing behind the superior mesenteric vein, courses upwards and to the right between the head of the pancreas and the duodenum, beneath the ascending layer of the transverse meso-colon, to anastomose with the superior pancreatico-duodenal, which is given off from the gastro-duodenal, and descends in a like situation beneath the ascending layer of the transverse meso-colon.

(2) The **middle colic,** arising from the concavity of the superior mesenteric a little below the pancreas, enters the transverse meso-colon, and divides into two branches—one of which passes to the left and anastomoses with the ascending branch of the left colic; the other, winding downwards and to the right, anastomoses with the ascending branch of the right colic.

FIG. 366.—THE SUPERIOR MESENTERIC ARTERY AND VEIN.

(The colon is turned up, and the small intestines are drawn over to the left side.)


TRANSVERSE COLON
ASCENDING COLON
DESCENDING COLON
PANCREAS
DUODENUM
Middle colic artery
Inferior pancreatico-duodenal artery
Right colic artery
Ileo-colic artery
CÆCUM
VERMIFORM APPENDIX
Left colic artery
Superior mesenteric artery and vein
JEJUNUM
Vasa intestini tenuis
SMALL INTESTINES

(3) The **right colic**—sometimes given off as a common trunk either with the former branch or with the ileo-colic—passes to the right behind the peritoneum to the back of the ascending colon, where it divides into an ascending branch, which anastomoses with the descending branch of the middle colic, and a descending branch which anastomoses with the ascending or colic branch of the ileo-colic.

(4) The **ileo-colic** descends behind the peritoneum towards the cæcum, where it divides into a colic branch which tracks upwards beneath the peritoneum to anastomose with the descending branch of the right colic; and into an ileac branch which passes between the layers of the mesentery and anastomoses with the termination of the superior mesenteric artery.

From the anastomotic loops formed between the termination of the superior mesenteric, the ileo-colic, the right colic, and the middle colic arteries, secondary loops are derived whence branches pass to the termination of the ileum, the cæcum, the vermiform appendix, the ascending colon, and half the transverse colon. These branches on reaching the intestine divide into two, one of which passes in front, and the other behind the intestine, and, after encircling it, anastomose with each other and with the neighbouring circlets above and below.

(5) The **intestinal branches, or vasa intestini tenuis,** arise from the convex side of the superior mesenteric, and, varying from twelve to sixteen in number, radiate in the mesentery, where each divides into two branches, which inosculate with similar branches given off from the branch above and below. From the primary loops thus formed, secondary loops are derived in like manner, and from these tertiary, and at times quaternary, or even quinary loops. From the ultimate loops terminal branches pass on to the intestine through the triangular interval left at the spot where the mesentery is reflected on to the muscular coat of the gut. On reaching the wall of the gut these terminal vessels bifurcate, the two branches encircling the intestine, and thus forming with those above and below a series of vascular rings surrounding the small intestine throughout its whole length. These branches of the superior mesenteric in their course to the intestine also supply the mesentery and the mesenteric glands.

The **variations in the superior mesenteric artery** are numerous. (A) It may be double. (B) It may give off accessory branches to the liver, stomach, pancreas, spleen, and gall-bladder. (C) It may give off branches normally derived from other sources, namely, the hepatic or its right or left branch, the cystic, the gastro-duodenal or its right gastro-epiploic branch, the gastric or the pancreatica magna. (D) It may give off the left colic and superior hæmorrhoidal, thus taking the place in whole or in part of the inferior mesenteric. (E) Its colic and intestinal branches may vary considerably in their origin and course, and in the number of primary and secondary loops that they form. (F) A rare abnormality described by Hyrtl is the persistence of an omphalo-mesenteric artery running to the neighbourhood of the umbilicus and giving off a branch to the urachus, or a branch to the liver through the falciform ligament, or a branch to the rectus anastomosing with the epigastric.

THE RENAL ARTERIES

The **renal arteries** come off one on each side of the abdominal aorta, a little below the superior mesenteric and first lumbar arteries, on a level with the first lumbar vertebra. They pass transversely outwards across the crura of the diaphragm to the kidneys, the right being on a slightly lower plane and somewhat longer than the left, and passing behind the inferior vena cava. In front of each is the corresponding renal vein. Behind each at the hilum of the kidney is the commencement of the ureter. Before entering the kidney they break up into three or four terminal branches. The distribution of the arteries in the kidney is described under the anatomy of that organ.

Each renal artery gives off the following branches:—

(*a*) The **inferior suprarenal,** which ascends to the suprarenal body.

(*b*) The **capsular** or **peri-renal branches** to the capsule of the kidney and peri-renal fat.

(*c*) The **ureteral branch** to the upper end of the ureter.

Variations in the renal arteries are common. (A) The right and left renal may arise from the aorta by a common stem. (B) They may arise from the aorta lower than usual; the kidneys then being also below their usual situation. (C) There may be several renal arteries on each side, or the renal artery may divide close to its origin into several branches. (D) The renal artery on one or both sides may arise from the bifurcation of the aorta, from the common iliac, the internal iliac, the inferior mesenteric, or the middle sacral artery. (E) The right artery may cross in front of, instead of behind, the vena cava. (F) The branches of the renal artery may perforate the substance of the kidney instead of entering at the hilum. (G) The renal artery may give origin to branches normally derived from other vessels, as the phrenic, the hepatic or its right branch from the right renal, the middle suprarenal, some of the colic arteries, the spermatic, one or more of the lumbar arteries, or the greater pancreatic artery. (H) Accessory renal arteries, varying in size and generally derived from the aorta, are common. They may enter the kidney at almost any part of the organ.

THE SUPRARENAL ARTERIES

The **capsular** or **suprarenal arteries** are derived from three sources, and are named as follows:—(1) Superior suprarenal; (2) middle suprarenal; and (3) inferior suprarenal.

(1) The **superior suprarenals,** one on each side, are usually derived from the phrenics, and descend to the suprarenal bodies.

(2) The **middle suprarenals,** or suprarenals proper, come off one on each side from the aorta, just above the first lumbar artery, and pass transversely outwards to the suprarenal bodies, across the crura of the diaphragm a little above the renal arteries. In the fœtus they equal the renals in size. In the adult they are much smaller.

(3) The **inferior suprarenals** are branches of the renals. They ascend, one on each side, to the suprarenal bodies.

The suprarenal veins, usually one on each side, terminate as a rule on the left side in the left renal; on the right side, in the inferior vena cava.

For the distribution of the suprarenal vessels within the suprarenal capsules, see page 1014.

THE SPERMATIC ARTERIES

The **spermatic arteries** come off from the front of the abdominal aorta. They diverge from each other as they descend over the aorta and psoas muscle to the deep or internal abdominal ring, where they are joined by the vas deferens, and, passing with it through the inguinal canal and out of the external or superficial abdominal ring, run downwards into the scrotum in a tortuous course to the testicle. They terminate in branches to the epididymis and body of that organ. Within the abdomen they lie beneath the peritoneum, and cross in their descent over the ureter and distal end of the external iliac artery; the right being superficial to the vena cava, and behind the termination of the ileum; and the left beneath the sigmoid flexure of the colon. In the inguinal canal and in the scrotum the spermatic veins lie in front of the artery, and the vas deferens lies behind it.

In the fœtus these vessels pass transversely outwards to the testicle, which in early fœtal life lies in the loin in front of the kidney; but as the testicles descend to the scrotum, the vessels become elongated, and are drawn with the testicle into the scrotum.

The spermatic arteries give off the following branches:—(1) Ureteral; (2) cremasteric; (3) epididymal; and (4) testicular.

(1) The **ureteral** are small branches given off to the ureter as the spermatic artery crosses it. They anastomose with the other ureteral branches derived from the renal, common iliac, and vesical arteries.

(2) The **cremasteric** are small branches given off to the cremaster muscle; they anastomose with the cremasteric branch of the deep epigastric.

(3) The **epididymal** are distributed to the epididymis, and anastomose with the artery of the vas.

(4) The **testicular** are the terminal branches of the spermatic; they perforate the tunica albuginea posteriorly, and are distributed to the body of the organ in the way mentioned in the section on the Testicle.

Chief variations in the spermatic arteries.—(A) One or both may be wanting, the testicle being then supplied by branches from the vesical or prostatic arteries passing under the arch of the pubis. (B) One or both may arise from the renal, more rarely from the suprarenal. (C) One may come off higher than the other. (D) They may come off from a common stem. (E) One or both may be double in the whole or part of their course. (F) The right spermatic may run behind instead of in front of the inferior vena cava.

THE OVARIAN ARTERIES

The **ovarian arteries** are the homologues of the spermatic arteries in the male, and correspond in their relations in the upper part of their course. They diverge somewhat less however, and on reaching the level of the common iliac artery turn inwards over that vessel and descend tortuously into the pelvis between the folds of the broad ligament to the ovaries. In the broad ligament the ovarian artery lies below the Fallopian tube, and on reaching the ovary turns backwards and supplies that organ (fig. 370).

They give off the following branches:—(1) Ureteral; (2) Fallopian; (3) uterine; and (4) ligamentous.

(1) The **ureteral** is distributed, as in the male, to the ureter.

(2) The **Fallopian** supplies the isthmus and ampulla of the Fallopian tube and its fimbriated extremity.

(3) The **uterine** runs along the Fallopian tube to the superior cornu of the uterus, which it supplies, together with the upper part of the fundus uteri, and anastomoses with the uterine arteries from the internal iliac.

(4) The **ligamentous** is distributed to the round ligament, passing with that structure through the inguinal canal, and anastomosing with the cremasteric and superficial external pudic arteries.

Like the spermatic, the ovarian arteries in the fœtus come off at right angles to the aorta, and pass transversely outwards to the ovaries, which are formed, as are the testicles, in the right and left loin in front of the kidneys. They elongate as the ovaries descend into the pelvis. During pregnancy these arteries undergo great enlargement.

THE INFERIOR MESENTERIC ARTERY

The **inferior mesenteric artery,** smaller than the superior, arises from the front of the abdominal aorta about an inch and a half above the bifurcation of that vessel. It runs obliquely downwards and to the left, across the lower part of the abdominal aorta and then over the left psoas muscle and left common iliac artery, descends into the pelvis between the layers of the meso-rectum, and terminates on the rectum in the superior hæmorrhoidal or superior rectal artery. It at first lies behind the peritoneum, or in the left lumbar meso-colon when that structure is present. It supplies the lower half of the large intestine. Its vein lies at first close to the left side, but soon passes upwards on the psoas, away from the artery, to end in the splenic vein (fig. 367).

The **branches of the inferior mesenteric** are:—(1) The left colic; (2) the sigmoid; and (3) the superior hæmorrhoidal.

(1) The **left colic** runs transversely outwards and to the left, beneath the peritoneum, and divides into two branches, one of which, entering the transverse meso-colon, ascends upwards and to the right, to anastomose with the middle colic. The other descends, and, entering the sigmoid meso-colon, anastomoses with the ascending branch of the sigmoid artery.

The distribution of this artery and the next to the colon is similar to that of the colic branches of the superior mesenteric, and does not require a separate description. (See Superior Mesenteric Artery, pages 559, 560.)

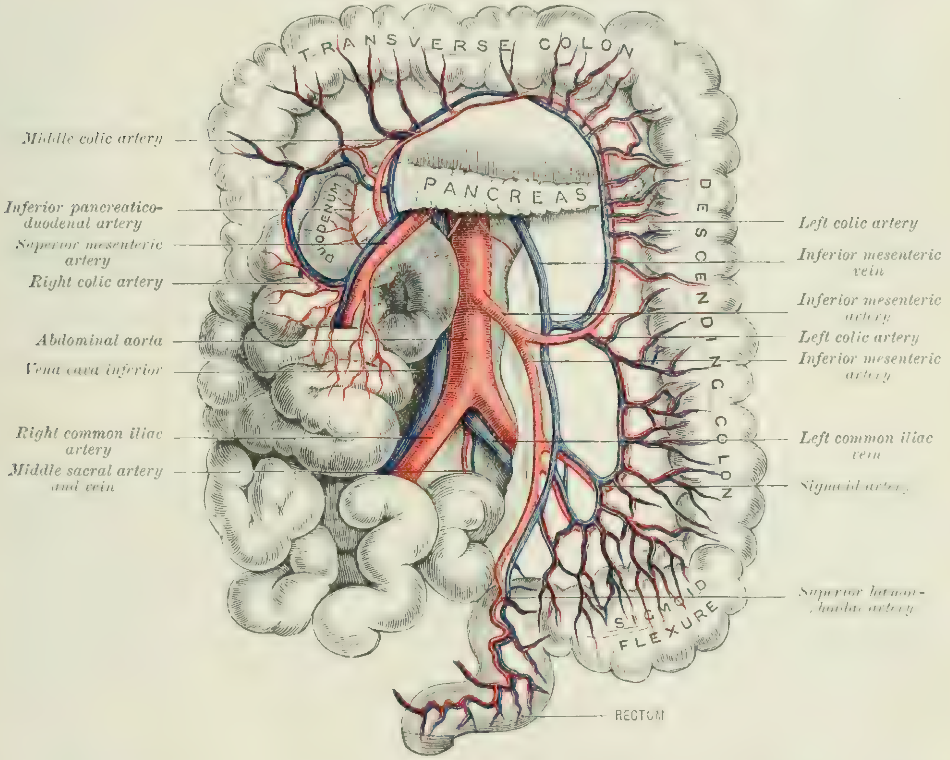
(2) The **sigmoid artery** runs downwards and to the left over the psoas muscle, and, entering the sigmoid meso-colon, divides into two branches; the upper anastomosing with the left colic, the lower with the superior hæmorrhoidal.

(3) The **superior hæmorrhoidal** is the continued trunk of the inferior mesenteric. It descends into the pelvis, behind the rectum, between the layers of the meso-rectum. On reaching the wall of the bowel it bifurcates, one branch proceeding on either side of the gut, to within four or five inches of the anus. Here each again divides, and the branches, piercing the muscular coat, descend between that coat and the mucous membrane, forming with each other, and with the middle hæmorrhoidal arteries—derived from the internal iliac—a series of small vessels, running longitudinally to the rectum, and parallel to each other as far as the level

of the internal sphincter, where, by their anastomosis, they form a series of loops around the lower part of the rectum.

The **chief variations** in the inferior mesenteric are :—(A) Its place may be supplied by the superior mesenteric. (B) It may give branches to the liver or kidney. (C) It may give off the middle colic. (D) It may give off a stem to both umbilical arteries. (E) The anastomosis between the middle and left colic arteries may be wanting—the normal condition in the ruminants and the porcupines.

FIG. 367.—THE INFERIOR MESENTERIC ARTERY AND VEIN.
(The colon is turned up, and the small intestines are drawn to the right side.)


TRANSVERSE COLON
PANCREAS
DUODENUM
DESCENDING COLON
SIGMOID FLEXURE
RECTUM
Middle colic artery
Inferior pancreatico-duodenal artery
Superior mesenteric artery
Right colic artery
Abdominal aorta
Vena cava inferior
Right common iliac artery
Middle sacral artery and vein
Left colic artery
Inferior mesenteric vein
Inferior mesenteric artery
Left colic artery
Inferior mesenteric artery
Left common iliac vein
Sigmoid artery
Superior hæmorrhoidal artery

C. THE TERMINAL BRANCHES OF THE ABDOMINAL AORTA

THE MIDDLE SACRAL ARTERY

The **middle sacral artery** is, anatomically, the continuation of the aorta, and is generally but not universally held to be the homologue of the sacral and coccygeal aorta of some animals. The so-called coccygeal glomerulus, or Luschka's gland, in which it terminates, is believed to contain the rudiments of the caudal aorta, or artery of the tail. The artery is mesially placed, and extends from the bifurcation of the aorta to the tip of the coccyx. As it passes downwards into the pelvis, it runs behind the left common iliac vein, the hypogastric plexus of the sympathetic nerve, and the layer of peritoneum that descends from the mesentery into the pelvis to become the meso-rectum. It lies successively upon the intervertebral disc between the fourth and fifth lumbar vertebræ, the fifth lumbar vertebra, the intervertebral disc between that vertebra and the sacrum, and lower down upon the middle of the anterior surface of the sacrum and coccyx.

Branches.—The middle sacral gives off:—

(1) The **fifth pair of lumbar arteries** (sometimes). These are described with the lumbar arteries.

(2) **Lateral sacral branches,** usually four in number. These are serially homologous with the intercostal and lumbar arteries given off by the aorta. They run more or less transversely outwards, and anastomose with the lateral sacral branches of the internal iliac artery. They give off small spinal branches, which pass through the sacral foramina, and supply the sacral canal and back of the sacrum.

(3) **Rectal** or **hæmorrhoidal branches** pass forwards in the layers of the mesorectum, to the rectum which they help to supply, and anastomose with the other hæmorrhoidal or rectal arteries.

On the lower part of the middle sacral artery—the coccygeal part—there are often found small pouches or varicosities, which are believed by some to represent the rudiments of lateral coccygeal arteries, homologous to the intercostal, lumbar, and sacral arteries, given off from the aorta in these regions.

The **variations** of this vessel are unimportant. (A) The most frequent perhaps is for it to come off from the back of the aorta a little above the bifurcation; or (B) from one or other of the common iliacs; or (C) as a common trunk with what are usually its branches, the fifth pair of lumbar arteries. (D) It sometimes gives off an accessory renal artery—a fact of interest, in that the kidneys occupy a lower position in the abdomen in some animals than in man.

THE COMMON ILIAC ARTERIES

The **common iliac arteries** must be regarded as the terminal branches of the abdominal aorta, unless the middle sacral and the artery of the tail in the lower animals are regarded as the continuation of the abdominal aorta. The common iliacs arise opposite the left side of the middle of the body of the fourth lumbar vertebra, at the bifurcation of the abdominal aorta, and, diverging from each other in the male at about an angle of 60°, and in the female at an angle of 68°, terminate opposite the lumbo-sacral articulation by bifurcating into the external iliac, which is continued along the brim of the pelvis to the lower limb, and into the internal iliac, which passes over the brim of the pelvis and descends into that cavity. Both arteries lie on the fifth lumbar vertebra, are covered by the peritoneum, and are crossed by the ureter, and in the female, in addition, by the ovarian arteries.

The relations of the arteries differ slightly on the two sides, and may be considered separately.

THE RIGHT COMMON ILIAC ARTERY

The **right common iliac** measures about two inches in length (5 cm.), and is rather longer than the left, in consequence of the aorta bifurcating a little to the left of the median line.

Relations.—**In front** it is covered by the peritoneum, and is crossed by the right ureter a little before its bifurcation, by the ovarian artery in the female, by the termination of the ileum, by the terminal branches of the superior mesenteric artery, and by branches of the sympathetic nerve descending to the hypogastric plexus.

Behind, it lies on the right common iliac vein, the end of the left common iliac vein, and the commencement of the inferior vena cava, which separate it from the fourth and fifth lumbar vertebræ and their intervening disc, the psoas muscle, and the sympathetic nerve; whilst still deeper in the groove between the fifth lumbar vertebra and the psoas are the lumbo-sacral cord, the obturator nerve, and the iliolumbar artery.

To the **right side** are the beginning of the inferior vena cava, the end of the right common iliac vein, and the psoas muscle, which, however, is separated from the artery by the inferior vena cava at its upper part.

To the **left side** are the right common iliac vein, the termination of the left common iliac vein, and the hypogastric plexus.

It will be thus seen that the right common iliac artery crosses both common iliac veins, and that its own vein, the right, is at first a little to the left side, but, as it ascends, passes beneath it, and gets a little to the right side. Since the bifurcation of the vena cava is a little below and to the right side of the bifurcation of the aorta, it follows that the right common iliac artery lies on the commencement of the vena cava.

THE LEFT COMMON ILIAC ARTERY

The **left common iliac artery,** one inch and three-quarters in length (4 cm.), is a little shorter and thicker than the right.

Relations.—In front it is covered by the peritoneum, which separates it from the intestines, and is crossed by the ureter, the ovarian artery in the female, branches of the sympathetic nerve descending to the hypogastric plexus, the termination of the inferior mesenteric artery, the sigmoid flexure, and the sigmoid meso-colon.

Behind are the lower border of the body of the fourth lumbar vertebra, the disc between the fourth and fifth lumbar vertebræ, the body of the fifth lumbar vertebra, and the disc between it and the sacrum. Crossing deeply behind the artery between the fifth lumbar vertebra and the psoas, is the obturator nerve, the lumbo-sacral cord, and the ilio-lumbar artery.

To the **left side** is the psoas muscle.

To the **right side** are the left common iliac vein, the hypogastric plexus, and the middle sacral artery.

Variations in the Common Iliac Arteries

(A) The common iliac arteries may be longer or shorter than here described. They have been found as short as half an inch, or as long as four and a half inches, but the usual limit is something between one and a half to three inches. This variation in the length of the vessels may depend upon the aorta bifurcating above or below the usual spot, or upon the common iliac arteries dividing higher or lower than usual. A low bifurcation of the aorta is somewhat more common than a high bifurcation, as is also the case with the common iliacs. (B) The common iliacs may be absent, the external and internal iliacs then arising together from the end of the aorta. (C) Either artery may give off a large branch, such as the ilio-lumbar, the lateral or the middle sacral, sometimes a lumbar, or occasionally an accessory renal artery.

Collateral Circulation

The **collateral circulation** after obstruction or ligature of the common iliac artery is carried on chiefly (fig. 374) by the anastomosis of the middle sacral with the lateral sacral; the internal mammary with the epigastric; the lumbar arteries of the aorta with the ilio-lumbar and deep circumflex iliac; the pubic branch of the epigastric with the pubic branch of the obturator; the posterior branches of the sacral arteries with the gluteal; the superior hæmorrhoidal from the superior mesenteric, with the hæmorrhoidal branches of the internal iliac and pudic; the ovarian arteries from the aorta with the uterine branches of the internal iliac; and by the anastomosis across the middle line of the pubic branch of the obturator with the like vessel of the opposite side; the lateral sacral with the opposite lateral sacral; and the vesical, hæmorrhoidal, uterine, and vaginal branches of the internal iliac with the corresponding branches of the opposite internal iliac.

BRANCHES OF THE COMMON ILIAC ARTERY

The **branches of the common iliac artery** are:—(1) Peritoneal and subperitoneal; (2) ureteral; (3) internal iliac; and (4) external iliac.

(1) The **peritoneal** and **subperitoneal** are distributed to the peritoneum and subperitoneal fat. They anastomose with like vessels given off from the lumbar, phrenic, and renal arteries, forming a subperitoneal arterial anastomosis. They are very small and unimportant.

(2) The **ureteral** are small insignificant twigs given off to the ureter as that duct crosses the artery. They anastomose with the ureteral arteries given off from the spermatic above, and with those derived from the vesical arteries below.

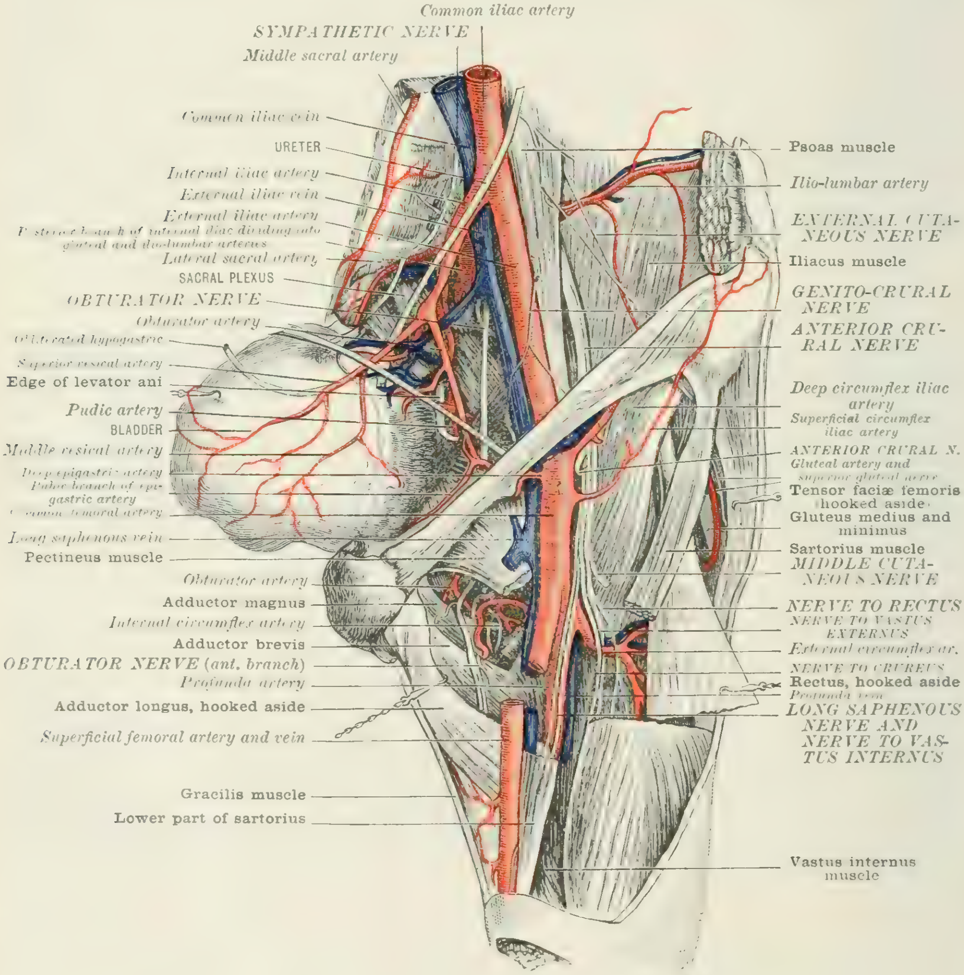
(3) THE INTERNAL ILIAC ARTERY

The **internal iliac artery** arises at the bifurcation of the common iliac opposite the lumbo-sacral articulation. It descends into the pelvis for about an inch and a quarter (3 cm.), and then divides, opposite the upper margin of the great sacro-sciatic foramen, into an anterior and a posterior branch.

FIG. 368.—SIDE VIEW OF PELVIS AND UPPER THIRD OF THIGH, WITH THE EXTERNAL ILIAC, INTERNAL ILIAC, AND FEMORAL ARTERIES AND THEIR BRANCHES, LEFT SIDE.

(From a dissection by W. J. Walsham in the Museum of St. Bartholomew's Hospital.)

The bladder is hooked over to expose back of pelvis.


Common iliac artery
SYMPATHETIC NERVE
Middle sacral artery
Common iliac vein
URETER
Internal iliac artery
External iliac vein
External iliac artery
Posterior branch of internal iliac dividing into gluteal and ilio-lumbar arteries
Lateral sacral artery
SACRAL PLEXUS
OBTURATOR NERVE
Obturator artery
Obliterated hypogastric
Superior vesical artery
Edge of levator ani
Pudic artery
BLADDER
Middle vesical artery
Deep epigastric artery
Pubic branch of epigastric artery
Common femoral artery
Long saphenous vein
Pectineus muscle
Obturator artery
Adductor magnus
Internal circumflex artery
Adductor brevis
OBTURATOR NERVE (ant. branch)
Profunda artery
Adductor longus, hooked aside
Superficial femoral artery and vein
Gracilis muscle
Lower part of sartorius
Psoas muscle
Ilio-lumbar artery
EXTERNAL CUTANEOUS NERVE
Iliacus muscle
GENITO-CRURAL NERVE
ANTERIOR CRURAL NERVE
Deep circumflex iliac artery
Superficial circumflex iliac artery
ANTERIOR CRURAL N.
Gluteal artery and superior gluteal nerve
Tensor faciæ femoris hooked aside
Gluteus medius and minimus
Sartorius muscle
MIDDLE CUTANEOUS NERVE
NERVE TO RECTUS
NERVE TO VASTUS EXTERNUS
External circumflex ar.
NERVE TO CRUREUS
Rectus, hooked aside
Profunda vein
LONG SAPHENOUS NERVE AND NERVE TO VASTUS INTERNUS
Vastus internus muscle

Relations.—Behind, it rests on the termination of the external iliac vein, the internal iliac vein, the inner margin of the psoas muscle, the lumbo-sacral cord, the obturator nerve, and the sacrum.

In front it is covered by the peritoneum, and is crossed by the ureter.

In the adult the internal iliac is smaller than the external iliac; but in the fœtus the internal is much larger than the external, and is, together with its anterior branch, the vessel by which the blood is returned to the placenta. In early fœtal life it does not descend into the pelvis, but courses above the pelvic brim by the side of the allantois, and later by the side of the bladder and urachus, to the umbilicus, under the name of the hypogastric artery. At the umbilicus it is joined by the umbilical vein, and by the hypogastric artery of the opposite side. The two arteries, now known as the umbilical, coil spirally round the vein on their way to the placenta, forming the umbilical cord (fig. 368). After birth the hypogastric artery ceases to be pervious beyond the superior vesical branch, and is converted into a fibrous cord, the obliterated hypogastric artery.

Variations.—(A) The **internal iliac** may be longer or shorter than usual. It is seldom less than an inch in length, but has been met with as short as half an inch, and as long as three inches. The variation in length generally depends upon the length of the common iliac; when this bifurcates higher than usual, the internal iliac is then longer, and may lie at first above the brim of the pelvis; but the length may also depend upon the artery itself dividing higher or lower than usual into its branches. This division may occur anywhere between the brim of the pelvis and the upper border of the sacro-sciatic foramen. (B) Its branches may be given off without the artery dividing into an anterior and a posterior division, or one or more branches may arise above the division.

The **branches of the posterior division of the internal iliac** are:—(1) The ilio-lumbar; (2) the lateral sacral; and (3) the gluteal.

The **branches of the anterior division** are:—(1) The hypogastric; (2) the superior, middle, and inferior vesical; (3) the middle hæmorrhoidal; (4) the uterine; (5) the vaginal; (6) the obturator; (7) the sciatic; and (8) the internal pudic.

Branches of the Posterior Division of the Internal Iliac Artery

1. THE ILIO-LUMBAR ARTERY

The **ilio-lumbar artery**—a short vessel coming off from the posterior part of the internal iliac artery—runs upwards and outwards beneath the common iliac artery, first between the lumbo-sacral cord and obturator nerve, and then between the psoas muscle and the vertebral column. On reaching the brim of the pelvis it divides into two branches, an iliac and a lumbar. The **iliac branch** passes outwards beneath the psoas and anterior crural nerve and, perforating the iliacus, ramifies in the iliac fossa between that muscle and the bone. It supplies a nutrient artery to the bone, and then breaks up into several branches which radiate from the parent trunk, upwards towards the sacro-iliac synchondrosis, outwards towards the crest of the ilium, downwards towards the anterior superior spine, and inwards towards the pelvic cavity. The first anastomoses with the last lumbar; the second with the external circumflex and gluteal; the third with the deep circumflex iliac from the external iliac; the fourth with the iliac branch of the obturator. The **lumbar branch** ascends beneath the psoas, and, supplying that muscle and the quadratus lumborum, anastomoses with the last lumbar artery. It sends a branch into the spinal canal through the intervertebral foramen between the last lumbar vertebra and the sacrum, which anastomoses with the other spinal arteries. The ilio-lumbar artery is serially homologous with the lumbar arteries. Hence the similarity in its course and distribution.

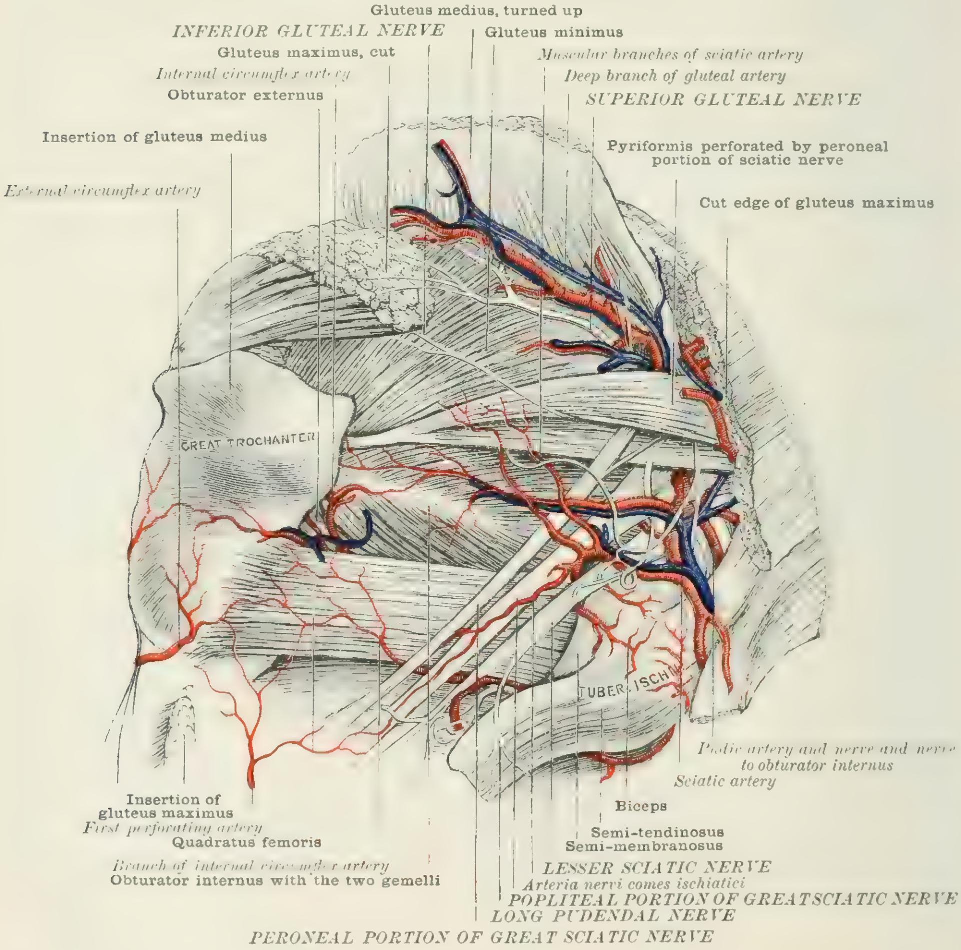
2. THE LATERAL SACRAL ARTERIES

The **lateral sacral arteries**, usually two in number, arise from the posterior division of the internal iliac. The **superior artery**, when two are present, runs downwards and inwards to the first anterior sacral foramen, through which it passes; and, after supplying the spinal membranes and anastomosing with the other spinal arteries, passes through the first posterior sacral foramen, and is distributed to the skin over the back of the sacrum, there anastomosing with branches of the gluteal and sciatic arteries. The **inferior lateral sacral** descends on the side of the sacrum, external to the sacral chain of the sympathetic, and internal to the anterior sacral foramina, crossing in its course the slips of origin of the pyriformis muscle and the first anterior sacral nerve. On reaching the coccyx it anastomoses in front of that bone with the middle sacral artery, and with the inferior lateral sacral of the opposite side. In this course it gives off:—**Posterior** or **spinal branches,** which enter the second, third, and fourth anterior sacral foramina, and, after supplying the spinal membranes and anastomosing with each other, leave the spinal canal by the corresponding posterior sacral foramina, and are distributed to the muscles and skin over the back of the sacrum; **anterior** or **rectal branches** which run forward to the rectum; **external branches** which are distributed to the pyriformis, coccygeus, and the sacral nerves; and **internal branches** which pass inwards across the sacrum to anastomose with branches of the middle sacral artery.

FIG. 369.—THE GLUTEAL REGION, WITH THE GLUTEAL, SCIATIC, AND PUDIC ARTERIES.

(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)

The inferior gluteal branch of the sciatic artery has been drawn inwards over the tuber ischii with the reflected origin of the gluteus maximus muscle.


Gluteus medius, turned up
INFERIOR GLUTEAL NERVE
Gluteus minimus
Gluteus maximus, cut
Muscular branches of sciatic artery
Internal circumflex artery
Deep branch of gluteal artery
Obturator externus
SUPERIOR GLUTEAL NERVE
Insertion of gluteus medius
Pyriformis perforated by peroneal portion of sciatic nerve
External circumflex artery
Cut edge of gluteus maximus
GREAT TROCHANTER
TUBER ISCHII
Pudic artery and nerve and nerve to obturator internus
Sciatic artery
Insertion of gluteus maximus
Biceps
First perforating artery
Quadratus femoris
Semi-tendinosus
Semi-membranosus
Branch of internal circumflex artery
Obturator internus with the two gemelli
LESSER SCIATIC NERVE
Arteria nervi comes ischiatici
POPLITEAL PORTION OF GREAT SCIATIC NERVE
LONG PUDENDAL NERVE
PERONEAL PORTION OF GREAT SCIATIC NERVE

At times the lateral sacral arteries are exceedingly small, the spinal branches then coming chiefly from the middle sacral. The anastomosing branches between the lateral sacral and middle sacral are usually regarded as sacral arteries diminished in size, and serially homologous with the lumbar and intercostal arteries.

3. THE GLUTEAL ARTERY

The **gluteal artery,** the largest branch of the posterior division of the internal iliac, comes off as a short, thick trunk from the outer and back part of that vessel, of which indeed it may be regarded as the continuation. Passing backwards between the first sacral nerve and the lumbo-sacral cord through an osseo-tendinous arch formed by the margin of the bone and the upper edge of the pelvic fascia, it leaves the pelvis through the great sacro-sciatic foramen above the pyriformis muscle in company with its vein and the superior gluteal nerve. At its exit posteriorly from the great sciatic foramen it lies under cover of the gluteus maximus and beneath the gluteal vein, and in front of the superior gluteal nerve. It here breaks up into two chief branches, a superficial and a deep. Its emergence from the pelvis is indicated on the surface by a point situated at the junction of the posterior with the middle third of a line drawn from the anterior superior to the posterior superior spine of the ilium.

Branches of the gluteal artery:—

(*a*) **Within the pelvis,** branches are distributed to the obturator internus, the pyriformis, the levator ani, the coccygeus, and the pelvic bones.

(*b*) **External to the pelvis,** the artery divides into a superficial and deep branch.

(i) The **superficial branch** breaks up into a number of large vessels for the supply of the upper portion of the gluteus maximus, some of them piercing the muscle and supplying the skin over it, and anastomosing with the posterior branches of the lateral sacral arteries; whilst one of larger size, emerging from the muscle near the iliac crest, anastomoses with the deep circumflex iliac artery. The lower branches to the muscle anastomose with branches of the sciatic.

(ii) The **deep branch** subdivides into a superior and an inferior branch. (*α*) The **superior** skirts along the line of origin of the gluteus minimus, between the gluteus medius and the bone, and, emerging in front from beneath these muscles under cover of the tensor fasciæ femoris (fig. 368), anastomoses with the ascending branch of the external circumflex and deep circumflex iliac arteries. (*β*) The **inferior branch** passes forwards between the gluteus medius and minimus, accompanied by the branch to the tensor fasciæ femoris of the inferior division of the superior gluteal nerve towards the great trochanter, where it anastomoses with the ascending branch of the external circumflex. It supplies branches to the contiguous muscles and to the hip-joint.

The deep branch before its division gives off the external nutrient artery of the ilium.

BRANCHES OF THE ANTERIOR DIVISION OF THE INTERNAL ILIAC ARTERY

1. THE HYPOGASTRIC ARTERY

The **hypogastric artery,** the main trunk of the internal iliac in the fœtus, is the apparent continuation of the anterior branch of the internal iliac. Passing forwards along the side of the pelvis, it enters the lateral false ligament of the bladder, where, after giving off one or more vesical branches, it ceases to be pervious as it passes on to the side and upper part of the bladder. Thence it ascends, under cover of the anterior false ligament, as a fibrous cord, to the umbilicus, where it is joined by its fellow of the opposite side. As it lies in the lateral false ligament it is crossed by the vas deferens.

2. THE VESICAL ARTERIES

The **vesical arteries** are divided into the superior, middle, and inferior.

(1) The **superior vesical artery**—though usually described as a branch of the internal iliac, inasmuch as it is apparently given off from the anterior division of

that vessel—is really a branch of the unobliterated portion of what, in the fœtus, was the hypogastric artery. It ramifies over the upper fundus of the bladder, anastomosing with the artery of the opposite side and with the middle and inferior vesical below. It gives off the following branches:—(*a*) The **deferential, or artery of the vas deferens,** arises from the superior vesical near the spot where the vas crosses the obliterated hypogastric artery, and, having reached the vas, divides into an ascending and a descending branch. The ascending branch follows the vas through the inguinal canal to the testicle, where it anastomoses with the spermatic artery. The descending branch passes downwards to the dilated portion of the vas and vesiculæ seminales. (*b*) The **uracheric branch** passes upwards along the urachus. (*c*) The **ureteric branches** pass to the lower end of the ureter, which they supply, and anastomose with the other ureteric arteries. (*d*) The **middle vesical** (sometimes).

(2) The **middle vesical** is a branch either of the superior vesical, or of the unobliterated portion of the hypogastric artery. In the latter case it is given off before the superior vesical. It is distributed to the sides and base of the bladder, and anastomoses with the other vesical arteries.

(3) The **inferior vesical** arises from the anterior division of the internal iliac, frequently in common with the middle hæmorrhoidal, and passes downwards and inwards to the base of the bladder, where it breaks up into branches which ramify over the lower part of the viscus. It gives off:—(*a*) Branches to the prostate, which supply that organ and anastomose with the arteries of the opposite side by means of descending arteries which pass through the prostatic plexus of veins, but outside the capsule of the prostate, and with the inferior hæmorrhoidal branches of the internal pudic. At times one of these prostatic branches is of large size, and supplies certain of the parts normally supplied by the internal pudic. It is then known as the **accessory pudic,** and then most commonly terminates as the dorsal artery of the penis. (*b*) Branches to the vesiculæ seminales; and (*c*) branches (in the female) to the vagina. (See VAGINAL ARTERY.) The artery of the vas deferens sometimes arises from the inferior vesical, instead of from the superior vesical.

3. THE MIDDLE HÆMORRHOIDAL ARTERY

The **middle hæmorrhoidal** or the **middle rectal artery,** variable in its origin, perhaps most commonly arises from the anterior division of the internal iliac along with the inferior vesical. It runs inwards to the sides of the middle portion of the rectum, dividing into branches which anastomose above with the superior hæmorrhoidal derived from the inferior mesenteric, and below with the inferior hæmorrhoidal derived from branches of the pudic. Its corresponding vein terminates in the inferior mesenteric vein.

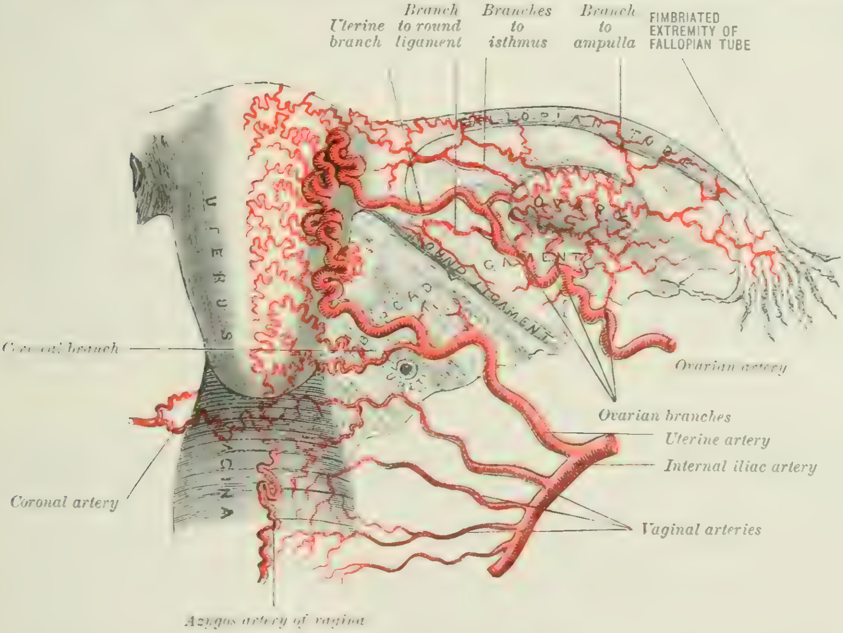
4. THE UTERINE ARTERY

The **uterine artery** arises from the anterior branch of the internal iliac close to or in conjunction with the middle hæmorrhoidal or inferior vesical. It runs downwards and inwards through the pelvic connective tissue in the so-called infundibulo-pelvic ligament, crossing the ureter about half an inch from the cervix uteri. It then turns upwards and ascends between the layers of the broad ligament on the side of the uterus in a coiled and tortuous manner, and, after giving off a number of tortuous branches which ramify in a horizontal manner over the front and back of the uterus, supplying its substance, anastomoses with the uterine branch of the ovarian artery. The distribution of the vessel in the uterus will be described with that organ. The **branches of the uterine artery** are:—(1) **Cervical.**—This branch comes off from the uterine as the latter artery crosses the ureter to turn upwards on to the uterus. It runs directly inwards, and divides into three or four branches which pass on to the cervix at right angles to it; one branch anastomosing with its fellow of the opposite side in front and behind the neck, forming the so-called coronary artery of the cervix. (2) **Vaginal azygos.**—A second branch descends both in front and behind in the middle line of the cervix on to the vagina, and forms, with branches of the vaginal arteries, the so-called azygos artery of the vagina.

5. THE VAGINAL ARTERIES

The **vaginal arteries** come off separately from the anterior division of the internal iliac, or one or more of them may arise in common with the inferior vesical, uterine, or middle hæmorrhoidal arteries. They are usually two or three in number. They pass through the pelvic connective tissue to the side of the vagina, supplying its walls, and anastomosing with the corresponding arteries of the opposite side, with each other, and with tortuous branches from the artery of the cervix, a branch of the uterine. With this vessel they form a more or less vertical trunk in the median line of the vagina, both back and front. This vessel is known as the **azygos artery of the vagina.** The lower vaginal arteries extend to the bulb of the vestibule, where they communicate with the bulbar branch of the internal pudic. Small branches extend also on to the rectum.

FIG. 370.—SCHEME OF THE OVARIAN AND UTERINE AND VAGINAL ARTERIES.


Uterine branch
Branch to round ligament
Branches to isthmus
Branch to ampulla
FIMBRIATED EXTREMITY OF FALLOPIAN TUBE
UTERUS
FALLOPIAN TUBE
OVARY
ROUND LIGAMENT
Cervical branch
Ovarian artery
Ovarian branches
Uterine artery
Internal iliac artery
Coronal artery
VAGINA
Vaginal arteries
Azygos artery of vagina

6. THE OBTURATOR ARTERY

The **obturator artery** comes off from the anterior division of the internal iliac at about the same spot as the hypogastric. Occasionally it arises from the posterior division. It runs forward and downwards a little below the brim of the pelvis, having the obturator nerve above, and the obturator vein below. It here lies between the peritoneum and the pelvic fascia, but pierces the fascia to gain the obturator canal, the aperture in the upper and outer part of the obturator membrane. In this course it is crossed by the vas deferens. On emerging from the obturator canal, the artery divides into two branches, an external and an internal, which wind round the margin of the thyroid foramen beneath the obturator externus muscle.

Within the pelvis the artery gives off:—(1) An iliac or nutrient branch; (2) a vesical branch; and (3) a pubic branch. Without the pelvis, it divides into:—(1) An external branch; and (2) an internal branch.

A. *Intra-pelvic branches.*—(1) The **iliac** or **nutrient branch** ascends to the iliac fossa, passing between the iliacus muscle and the bone. It supplies a nutrient vessel to the ilium, and anastomoses with the internal branch of the iliac division of the ilio-lumbar artery.

(2) The **vesical branch** or branches are small vessels which run in the lateral false ligament of the bladder to that organ, where they anastomose with the other vesical arteries.

(3) The **pubic branch** comes off from the obturator as that vessel is leaving the pelvis by the obturator canal. It runs upwards and inwards behind the pubes, anastomosing with its fellow of the opposite side of the body, and with the pubic branch of the deep epigastric artery. One of the anastomosing channels between the pubic branch of the obturator and pubic branch of the deep epigastric arteries is sometimes of large size, a fact of surgical interest in that the enlarged vessel may then run round the inner side of the femoral ring (page 579).

B. *Extra-pelvic branches.*—(1) The **external branch** skirts the external margin of the thyroid foramen, lying between the obturator externus and the obturator membrane. At the lower margin of the foramen it divides into two branches. One branch continues its course round the lower margin of the foramen, and anastomoses with the internal branch of the obturator and with the internal circumflex. The other branch turns outwards below the acetabulum, and ends in the muscles arising from the tuberosity of the ischium. It anastomoses with the sciatic artery. This branch gives off a small twig which passes under the transverse ligament into the hip-joint, where it supplies the synovial membrane, the ligamentum teres, and the fat in the fossa at the bottom of the acetabulum.

(2) The **internal branch** runs round the inner margin of the thyroid foramen, and anastomoses with the inner division of the external branch and with the internal circumflex artery. It supplies branches to the obturator and adductor muscles.

7. THE SCIATIC ARTERY

The **sciatic artery**—the larger of the terminal branches of the anterior division of the internal iliac—passes over the sacral plexus and pyriformis muscle to the lower part of the great sciatic foramen, where it leaves the pelvis with the pudic artery, behind and external to which it lies, by passing between the pyriformis and coccygeus muscles. On emerging from the great sciatic foramen in the gluteal region under cover of the gluteus maximus, it descends to the inner side of the great sciatic nerve, lying midway between the tuberosity of the ischium and the great trochanter on the gemellus superior, obturator internus, gemellus inferior, quadratus femoris, and upper part of the adductor magnus muscles. It anastomoses with the internal circumflex artery, and superior perforating branch of the profunda. The **branches of the sciatic artery** are divided into the intra- and extra-pelvic.

The **intra-pelvic branches** are small and unimportant, and irregular in their origin and distribution. They are given off to the levator ani, coccygeus, and pyriformis muscles, the rectum, bladder, prostate gland, and vesiculæ seminales.

The **extra-pelvic branches** are: (1) The coccygeal; (2) inferior gluteal; (3) muscular; (4) anastomotic; (5) articular; (6) cutaneous; and (7) comes nervi ischiatici.

(1) The **coccygeal** is a small branch which passes inwards, and, piercing the great sacro-sciatic ligament and the gluteus maximus, is lost in the integument over the lower part of the sacrum and coccyx. It gives several branches to the lower and internal part of the gluteus maximus as it passes through it.

(2) The **inferior gluteal** is a fairly large branch which arises from the sciatic just below the coccygeal, and, turning upwards and inwards into the deep surface of the gluteus maximus along with the inferior gluteal nerve, supplies that muscle, and anastomoses with the gluteal artery.

(3) The **muscular branches**, variable in their number and origin, pass to the

pyriformis, obturator internus, and gemelli muscles, anastomosing with the pudic, the internal circumflex, and the obturator arteries.

(4) The **anastomotic branch** crosses the external rotator muscles either over or under the great sciatic nerve, and contributes to the formation of the so-called **crucial anastomosis** by anastomosing with the first perforating below, the termination of the internal circumflex internally, and the transverse branch of the external circumflex externally (fig. 369).

(5) The **articular branches** pass beneath the external rotator muscles with the nerve to the quadratus femoris, and send several filaments into the posterior part of the capsule of the hip-joint.

(6) The **cutaneous branches** turn round the lower border of the gluteus maximus, along with branches of the small sciatic nerve, and supply the integument of that region.

(7) The **comes nervi ischiatici** is a long slender vessel which passes down the back of the thigh with the great sciatic nerve, to which it sends numerous branches. It anastomoses with the internal circumflex, and with the first, second, and third perforating arteries, and with the termination of the profunda, or fourth perforating. After ligature of the femoral in Scarpa's triangle, this artery becomes greatly enlarged, and contributes through its anastomosis with the above-mentioned arteries to the supply of the parts below the ligature.

8. THE INTERNAL PUDIC ARTERY

The **internal pudic artery**—the smaller of the two terminal branches of the anterior division of the internal iliac artery—comes off with the sciatic, the other terminal branch, either separately or as a common trunk, opposite the pyriformis muscle. It descends with the sciatic over the pyriformis and sacral plexus of nerves, lying anterior and internal to the latter artery as far as the lower border of the great sciatic foramen, where it passes out of the pelvis between the pyriformis and coccygeus muscles. It then winds over the outer surface of the spine of the ischium under cover of the gluteus maximus, and re-enters the pelvis through the lesser sciatic notch. Running forwards over the obturator internus muscle, it passes through the base of the triangular ligament, and, continuing its course along the ramus of the pubes, gives off between the two layers of the triangular ligament the artery of the crus and the artery of the bulb, and is continued through the anterior layer of the ligament as the dorsal artery of the penis.

The **relations of the artery** may be considered:—(1) As it lies within the pelvis; (2) as it crosses the spine of the ischium; (3) as it lies on the obturator internus muscle, in the outer wall of the ischio-rectal fossa; and (4) as it lies between the two layers of the triangular ligament.

(1) **Within the pelvis** the artery crosses the pyriformis muscle and sacral plexus of nerves, lying somewhat anterior and internal to the sciatic artery, which is usually given off from the internal iliac along with it. At the lower border of the sciatic foramen it leaves the pelvis by passing between the pyriformis and coccygeus muscles along with the sciatic artery, the pudic nerve, the greater and lesser sciatic nerves, and the nerve to the obturator internus.

(2) **As it crosses the spine of the ischium** it has a companion vein on either side, the pudic nerve on its inner side, and the nerve to the obturator internus on its outer side. It is covered by the gluteus maximus muscle, and more or less by the overlapping edge of the great sacro-sciatic ligament. In a thin subject it can be felt pulsating as it crosses the ischial spine. A spot taken at the junction of the inner with the outer two-thirds of a line drawn from the top of the great trochanter with the femur rotated inwards to the base of the coccyx, indicates externally the situation of the artery as it crosses the ischial spine. In this situation it may, in a thin subject, be compressed. The **branches of the artery** in this part of its course are: (*a*) Small twigs to the gluteus maximus; (*b*) a small branch to the obturator internus which accompanies the nerve to that muscle; (*c*) a sacral branch which pierces the great sciatic ligament and anastomoses with the sciatic artery.

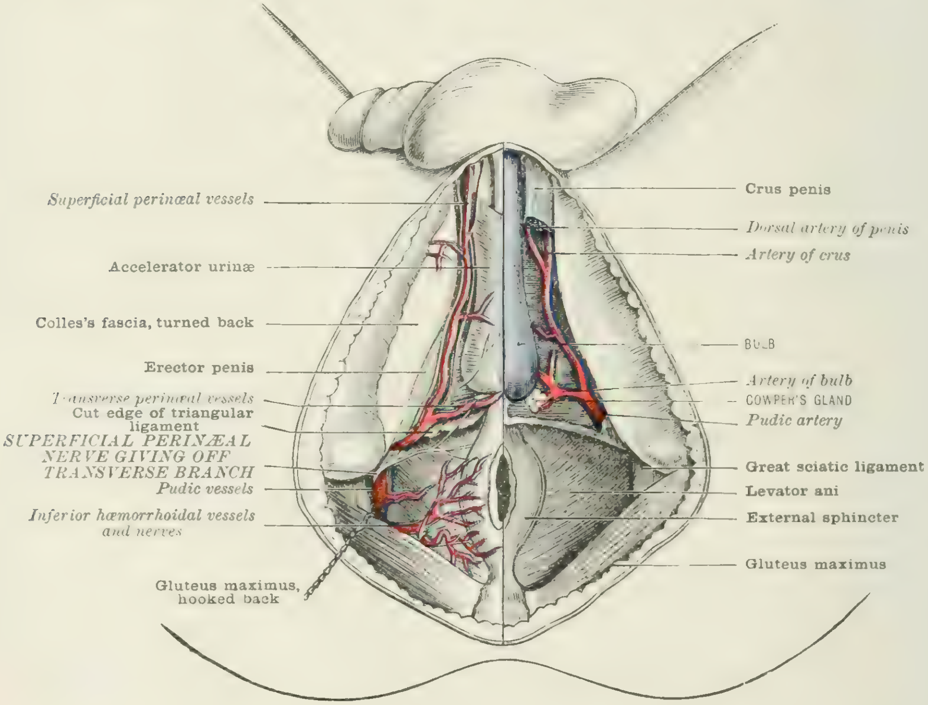
(3) In the **third part of its course**, as it lies on the obturator internus muscle, in the outer wall of the ischio-rectal fossa, it is placed about an inch and a half (3·5 cm.) above the lower margin of the tuberosity of the ischium. It is here bound down to the muscle by a strong sheath of the obturator layer of the pelvic fascia (Alcock's canal). In this part of its course the dorsal nerve of the penis and the superficial perinæal nerve, into which the pudic nerve divides about this situation, lie respectively above and below the artery.

The **branches of the pudic artery** in the third part of its course are:—(*a*) The external or inferior hæmorrhoidal; and (*b*) the superficial perinæal.

(*a*) The **external** or **inferior hæmorrhoidal branches** (inferior or posterior anal) are given off from the pudic at the posterior part of the ischio-rectal fossa, just after it enters the outer wall of that cavity through the lesser sciatic foramen. They perforate the sheath of obturator fascia binding the pudic artery to the obturator internus, and course transversely through the fat of the ischio-rectal fossa, inwards to the anus, where they supply the sphincter muscle and levator ani, and anastomose with the superior and middle hæmorrhoidal arteries. Twigs are given off from them to the skin covering the anal triangle of the perinæum; other branches supply the gluteus maximus and wind over the posterior fold of that muscle to the integuments; whilst others again run forwards and anastomose with the transverse and superficial perinæal arteries (fig. 370A).

FIG. 370A.—THE ARTERIES OF THE PERINÆUM.

On the right side Colles's fascia has been turned back to show the superficial vessels. On the left side the superficial vessels have been cut away with the anterior layer of the triangular ligament to show the deep vessels.

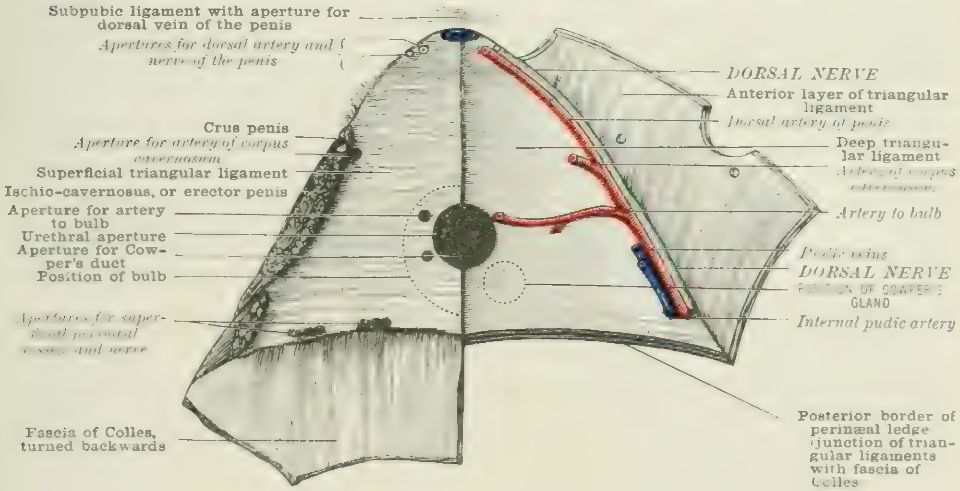

Superficial perinœal vessels
Accelerator urinæ
Colles's fascia, turned back
Erector penis
Transverse perinœal vessels
Cut edge of triangular ligament
SUPERFICIAL PERINÆAL NERVE GIVING OFF TRANSVERSE BRANCH
Pudic vessels
Inferior hæmorrhoidal vessels and nerves
Gluteus maximus, hooked back
Crus penis
Dorsal artery of penis
Artery of crus
BULB
Artery of bulb
COWPER'S GLAND
Pudic artery
Great sciatic ligament
Levator ani
External sphincter
Gluteus maximus

(*b*) The **superficial perinæal branch** arises from the pudic at the front of the ischio-rectal fossa, just before that vessel pierces the posterior layer of the triangular ligament. It passes through the deep layer of the superficial fascia of the perinæum (Colles's fascia), where that structure is continued into the anterior layer of the triangular ligament round the transverse perinæal muscle. It then crosses in front of (occasionally behind) that muscle, and enters the perinæal triangle, the space between Colles's fascia and the anterior layer of the triangular ligament, bounded by the erector penis externally, the accelerator urinæ internally, and the transverse perinæal muscle below. On nearing the apex of this triangle it divides into long slender branches, which are continued along the back of the scrotum, anastomosing with the superficial external pudic branch of the common femoral. In this course it is accompanied by the superficial perinæal nerve. It supplies the contiguous muscles and the integuments of the scrotum. As a rule it gives off the following branch:—

The **transverse perinæal artery** usually arises from the before-mentioned artery. Occasionally it is a direct branch from the pudic trunk. It courses transversely inwards, on the transverse perinæal muscle, towards the central tendon of the perinæum, supplying the muscles and integuments of the perinæum, and anastomosing with its fellow of the opposite side.

(4) In the **fourth part of its course** the pudic artery lies between the two layers of the triangular ligament, close to the ramus of the pubes, in the substance of the compressor urethræ muscle, having the anterior layer of the triangular ligament in front and the posterior layer behind. In this situation it gives off the artery of the bulb and the artery of the crus penis, and then continues its course forwards through the anterior layer of the triangular ligament under the name of the dorsal artery of the penis.

FIG. 371.—SCHEME OF THE PUDIC ARTERY AND ITS BRANCHES.


Subpubic ligament with aperture for dorsal vein of the penis
Apertures for dorsal artery and nerve of the penis
Crus penis
Aperture for artery of corpus cavernosum
Superficial triangular ligament
Ischio-cavernosus, or erector penis
Aperture for artery to bulb
Urethral aperture
Aperture for Cowper's duct
Position of bulb
Apertures for superficial perinæal vessels and nerve
Fascia of Colles, turned backwards
DORSAL NERVE
Anterior layer of triangular ligament
Dorsal artery of penis
Deep triangular ligament
Artery of corpus cavernosum
Artery to bulb
Pudic veins
DORSAL NERVE
POSITION OF COWPER'S GLAND
Internal pudic artery
Posterior border of perinæal ledge (junction of triangular ligaments with fascia of Colles

The **branches of the pudic artery** in the fourth part of its course are:—(*a*) The artery of the bulb; (*b*) the artery of the crus; and (*c*) the dorsal artery of the penis.

(*a*) The **artery of the bulb**, often of large size, comes off from the pudic soon after that vessel has passed between the two layers of the triangular ligament. It runs inwards and slightly upwards behind the anterior layer of the triangular ligament, embedded more or less in the substance of the compressor urethræ muscle. On nearing the urethra, it passes forwards through a hole in the anterior layer of the triangular ligament (fig. 371), by the side of the opening for the urethra, and, entering the bulb, supplies the erectile tissue of the bulb and corpus spongiosum in the way described under the anatomy of the urethra. It gives off a branch, just before piercing the anterior layer of the triangular ligament, to Cowper's glands (fig. 370A).

The situation of the artery of the bulb should be remembered in performing the operation of lateral lithotomy. As a rule, the artery is well above the central tendon of the perinæum. If the point of the knife is entered below this spot, and care is taken not to direct its point subsequently too much upwards so that the deeper part of the incision is not made higher than the superficial, the artery will not be endangered. At times, however, the artery is given off from the pudic lower than normal. Its division may then be unavoidable.

When the artery is given off, as it occasionally is, from the accessory pudic, it pierces the anterior layer of the triangular ligament higher up, and is out of danger in the ordinary low operation of lateral lithotomy. Further, the artery of the bulb may be absent on one side, smaller than usual, or double.

In the female, the artery of the bulb, smaller than in the male, ends in the bulb of the vestibule.

(*b*) The **artery of the crus** is usually given off from the pudic a little higher than the artery of the bulb. It makes at once for the ramus of the pubes, perforates the anterior layer of the triangular ligament close to the bone, and enters the crus penis (figs. 370A, 371). This artery has to be divided in the operation for the removal of the whole of the penis by dissecting off the crura from the rami of the pubis and ischium. Its situation close to the bone at times gives rise to some little trouble in securing it. A small additional artery to the corpus spongiosum is occasionally given off from this branch and then contributes to the supply of that structure and inosculates with branches from the artery to the bulb.

In the female, the artery ends in the crus clitoridis.

(*c*) The **dorsal artery of the penis** (fig. 371), the termination of the pudic, passes upwards between the two layers of the triangular ligament in the substance of the compressor urethræ muscle; then, turning forwards, perforates the anterior layer of the triangular ligament, near its apex, a little to one side of the central apical opening for the dorsal vein. It then passes between the two layers of the suspensory ligament of the penis, and descends along the dorsum of that organ, the single centrally placed dorsal vein separating it from the artery of the opposite side. The dorsal nerve lies to the outer side of the artery, and, still more external, the deep external pudic branch of the common femoral artery. At the glans the dorsal artery forms an anastomotic chain around the corona with the vessel of the opposite side. The superficial external pudic branch of the femoral at times may take the place of the dorsal artery. Occasionally the dorsal artery is found to arise from the inferior vaginal; that is, from an enlarged branch of the vessel known as the accessory pudic (see page 570).

In the female, the termination of the pudic is called the **dorsal artery of the clitoris.**

The dorsal artery gives branches to—(*a*) The corpus cavernosum; (*b*) the skin of the penis; (*c*) the glans penis; and **in the female,** (*d*) the glans and prepuce of the clitoris.

THE EXTERNAL ILIAC ARTERY

The **external iliac artery**—the larger in the adult of the two vessels into which the common iliac divides opposite the lumbo-sacral articulation—extends from this spot along the brim of the pelvis, lying upon the inner border of the psoas muscle, to the lower margin of Poupart's ligament, where, midway between the anterior superior spine of the ilium and the symphysis pubis, it passes into the thigh, and takes the name of the femoral.

It measures three and a half to four inches (10 cm.) in length. The course of the vessel is indicated by a line drawn from half an inch below and a little to the left of the umbilicus, to a point a little internal to the centre of Poupart's ligament, that is, to a spot midway between the symphysis pubis and the anterior superior spine of the ilium. If this line is divided into thirds, the lower two thirds indicate the situation of the external iliac, the upper third the common iliac. The external iliac vein, the continuation upwards of the femoral vein from the thigh, lies to the inner side of the artery, but on a slightly lower plane, and just before its termination gets a little behind the artery on the right side.

Relations.—In front, the artery together with the vein is covered by the parietal peritoneum descending from the abdomen into the pelvis, and by a layer of condensed subperitoneal tissue, known as Abernethy's fascia. It is crossed by the termination of the ileum on the right side, and by the sigmoid flexure on the left. The genital branch of the genito-crural nerve runs obliquely over its lower third, and just before its termination it is crossed transversely by the deep circumflex iliac vein. The spermatic vessels lie for a short distance on the lower part of the artery, and the vas deferens in the male and the ovarian vessels in the female curve over it to descend to the pelvis. It is sometimes crossed at its origin by the ureter. The external iliac lymphatic glands lie along the course of the artery. The commencement of its deep epigastric branch is also in front.

Behind.—At first the artery lies partly upon its own vein; lower down upon the inner border of the psoas; and just before it passes through the lacuna vasculosa, beneath Poupart's ligament, upon the tendon of the psoas. The continuation of the iliac into the pelvic fascia is also below it.

To its **inner side** is the external iliac vein, the peritoneum, the descending layer of fascia, and the vas deferens in the male, and ovarian vessels in the female.

To its **outer side** is the psoas muscle and the iliac fascia.

Variations.—(A) The external iliac may be longer or shorter than usual, according as the common iliac bifurcates above or below the usual spot. When longer it often takes a very tortuous course, making a partial loop or bend which may dip down below the brim of the pelvis. (B) It may be much smaller in size than usual; this is especially the case in those instances in which the femoral or main vessel of the lower limb arises from the sciatic or other branch of the internal iliac. It then often ends in the profunda. (C) It may give off a large branch, as the deep circumflex iliac or deep epigastric, higher than usual.

The **collateral circulation** is carried on (fig. 372), when the external iliac is tied, by the anastomosis of the ilio-lumbar and lumbar arteries with the circumflex iliac; the internal mammary with the deep epigastric; the obturator with the internal circumflex; the sciatic with the internal circumflex and superior perforating; the gluteal with the external circumflex; the arteria comes nervi ischiatici from the sciatic, with the perforating branches of the profunda; the external pudic with the internal pudic; the pubic branch of the obturator with the pubic branch of the epigastric.

The **branches of the external iliac artery** are:—(1) The deep epigastric; (2) the deep circumflex iliac; and (3) several small and insignificant twigs to the neighbouring psoas muscle and lymphatic glands.

(1) THE DEEP EPIGASTRIC ARTERY

The **deep epigastric artery** usually comes off from the external iliac just above Poupart's ligament. Immediately after its origin, the vas deferens in the male, and the round ligament in the female, loop round it on their way to the pelvis, drawing, as it were, the artery slightly inwards and downwards. It here lies internal to the inner margin of the deep or internal abdominal ring behind the inguinal canal, and a little to the upper and outer side of the femoral ring. Thence it passes upwards and inwards, above and to the outer side of the superficial or external abdominal ring, lying between the fascia transversalis and the peritoneum to the lower margin of the posterior layer of the sheath of the rectus (fold of Douglas). Having pierced the fascia transversalis at this point, it passes in front of Douglas' fold and turns upwards between the rectus and its sheath, lying here about midway between the outer and inner edge of the muscle. Higher, it enters the substance of the muscle, and anastomoses with the superior epigastric, descending in the rectus from the internal mammary.

The situation of the artery between the two abdominal rings should be borne in mind in the operation for strangulated inguinal hernia, and its near proximity to the upper and outer side of the femoral ring should not be forgotten in the operation for femoral hernia. The artery is accompanied by two veins, of which the inner is the larger. They end in a single trunk before opening into the external iliac vein.

The deep epigastric gives off the following small branches:—(*a*) The **cremasteric,** which runs with the vas through the inguinal canal, supplies the cremaster muscle, and anastomoses with the spermatic, inferior external pudic, and superficial perinæal arteries. (*b*) The **pubic,** which passes below, or sometimes above, the femoral ring to the back of the pubes, where it anastomoses with the pubic branch of the obturator and the corresponding vessel of the opposite side. This branch, though usually small, is occasionally considerably enlarged, when its exact course becomes of great interest to the surgeon. Thus it may descend immediately internal to the vein, and therefore external to the femoral ring, or it may pass inwards in front of the femoral ring and turn downwards either behind the os pubis or immediately behind the free edge of Gimbernat's ligament, in which situation it would be exposed to injury in the operation for the relief of a strangulated femoral hernia. (*c*) The **muscular,** which supply the rectus and the oblique and transverse muscles of the abdomen, and anastomose with the lower intercostal and the lumbar arteries. (*d*) The **cutaneous,** which pierce the rectus, and supply the skin, anastomosing with branches of the superficial epigastric. And (*e*) the **terminal,** which anastomose above the umbilicus with the superior epigastric branch of the internal mammary.

Variations.—(A) The epigastric may come off from the external iliac higher than usual; it has been met with arising as much as two inches and a half above Poupart's ligament. (B) It may arise from the femoral below Poupart's ligament, or even from the profunda. (C) It may arise as a common trunk with the circumflex iliac. (D) It is sometimes double. (E) It may arise from the obturator, or conversely it may give off the obturator artery. This variation is due to the enlargement of the normal anastomosis of the epigastric and obturator through their pubic branches. It is of considerable importance to the surgeon, since the obturator artery, when given off from the epigastric, may run either external or internal to the femoral ring to reach the obturator foramen. This abnormal origin of the obturator is said to occur once in every three subjects and a half; but the abnormal artery only courses round the inner side of the ring—in which situation it is liable to injury in the operation for femoral hernia—in exceptional cases. According to Langton (Holden's 'Anatomy'), the chances are about seventy to one against this occurring. But even when it takes the abnormal course, it lies a line and a half or so from the margin of the ring, and will probably escape injury in the division of the stricture if several short notches are made in place of a single and longer incision.

(2) The Deep Circumflex Iliac Artery

The **deep circumflex iliac** arises from the outer side of the external iliac artery, either opposite the epigastric or a little below the origin of that vessel. It courses upwards and outwards just above the lower margin of Poupart's ligament, lying between the fascia transversalis and the peritoneum, or at times in a fibrous canal formed by the union of the fascia transversalis with the iliac fascia. Near the anterior superior spine of the ilium, it perforates the transversalis, and then courses between that muscle and the internal oblique, along and a little above the crest of the ilium. It finally divides into an ascending branch, which anastomoses with the lumbar and lower intercostal arteries, and a marginal branch which runs backwards to anastomose with the ilio-lumbar artery. It is accompanied by two veins. These unite into one trunk, which then crosses the external iliac artery to join the external iliac vein.

The deep circumflex iliac artery gives off the following branches:—(*a*) **Muscular branches,** which supply the psoas, iliacus, sartorius, tensor fasciæ femoris, and the oblique and transverse muscles of the abdomen. One of these branches, larger than the rest, usually arises about an inch behind the anterior superior spine of the ilium and ascends perpendicularly between the transversalis muscle and the internal oblique. It has received no name but is important to the surgeon, as it indicates the intermuscular plane between the two muscles. (*b*) **Cutaneous branches,** which supply the skin over the course of the vessel, and anastomose with the superficial circumflex iliac, the gluteal, and the ascending branch of the external circumflex.

Variations.—(A) The **circumflex iliac,** like the epigastric, may be given off from the external iliac higher than normal, though seldom if ever as high as the latter. (B) More rarely it may come off from the femoral below Poupart's ligament. (C) It may arise as a common trunk with the epigastric. (D) It may be double.

THE FEMORAL ARTERY

The **femoral artery** (fig. 372) is the continuation of the external iliac, and extends from the lower border of Poupart's ligament, down the front and inner part of the thigh, to the tendinous opening in the adductor magnus, through which it passes into the popliteal space, and is then known as the popliteal. The femoral artery is at first quite superficial, being merely covered by the skin, and superficial and deep fascia; but, after thus passing about five inches (13 cm.) in a direction downwards and inwards through the space known as Scarpa's triangle, it sinks at the apex of that triangle beneath the sartorius muscle, and thence to its termination continues beneath the sartorius, coursing deeply between the vastus internus and adductor muscles in the space known as Hunter's canal. It at first rests upon the brim of the pelvis and head of the thigh bone, from which it is merely separated by the capsule of the hip-joint and the tendon of the psoas. Here it can be readily compressed. Owing to the obliquity of the neck of the femur and the direct course taken by the artery, it lies lower down only on muscles, at some little distance from the bone (fig. 373). At its termination, in consequence of the shaft of the femur inclining towards the middle line of the body, the artery lies close to the bone, but to the inner side. The course of the vessel when the thigh is slightly flexed and abducted—the position in which the limb is placed when the vessel is ligatured—is indicated by a line drawn from a spot midway between the anterior superior spine of the ilium and the symphysis pubis to the adductor tubercle. When the thigh is in the extended position and parallel to its fellow, the course of the artery will correspond to a line drawn from the spot above-mentioned to the inner border of the patella.

The artery for about the first inch and a half to two inches (4 to 5 cm.) is known as the common femoral, but at this distance from Poupart's ligament it gives off a large branch called the profunda, or deep femoral. For the rest of its course it is known as the superficial femoral. The superficial femoral is only superficial where it lies in Scarpa's triangle—that is, for about three and a half inches (9 cm.) of its course; the remainder of the artery being deeply placed in Hunter's canal, though less deeply than the profunda, or deep femoral. The details of the anatomy of the femoral will perhaps best be studied by considering the relations of (1) the common femoral; (2) the superficial femoral as it lies in Scarpa's triangle; and (3) the superficial femoral as it lies in Hunter's canal.

(1) **The relations of the common femoral artery.—In front,** the common femoral (fig. 372) is covered by the skin, the superficial fascia, the iliac portion of the fascia lata, the crural branch of the genito-crural nerve, the superficial circumflex iliac vein, and sometimes the superficial epigastric vein. The fascia transversalis, which is continued downwards into the thigh beneath Poupart's ligament, is also one of its anterior relations, but soon becomes indistinguishable from the sheath of the vessel.

Behind, the artery rests upon the tendon of the psoas muscle, which separates it from the brim of the pelvis and capsule of the hip-joint, and, a little lower, on the pectineus, more or less loose fat and cellular tissue intervening. The branches of the anterior crural nerve to the pectineus muscle also pass behind it.

A similar prolongation to that derived from the fascia transversalis in front descends behind the vessel from the iliac fascia; but, like the anterior prolongation of fascia, soon blends with the sheath of the vessels.

To the **inner side** is the femoral vein, but separated from the artery in the upper part of its course by a thin layer of fascia passing from the continuation of the iliac fascia behind the vessels, to the continuation of the fascia transversalis in front of the vessels.

To the **outer side** is the leash of nerves known as the anterior crural. These are, however, separated from the artery by a few fibres of the psoas muscle.

(2) **The relations of the superficial femoral artery in Scarpa's triangle** (fig. 372).—**In front,** the artery is covered by the skin and by the superficial and deep fascia, and is crossed at the lower part of Scarpa's triangle by a branch of the internal cutaneous nerve. The crural branch of the genito-crural nerve

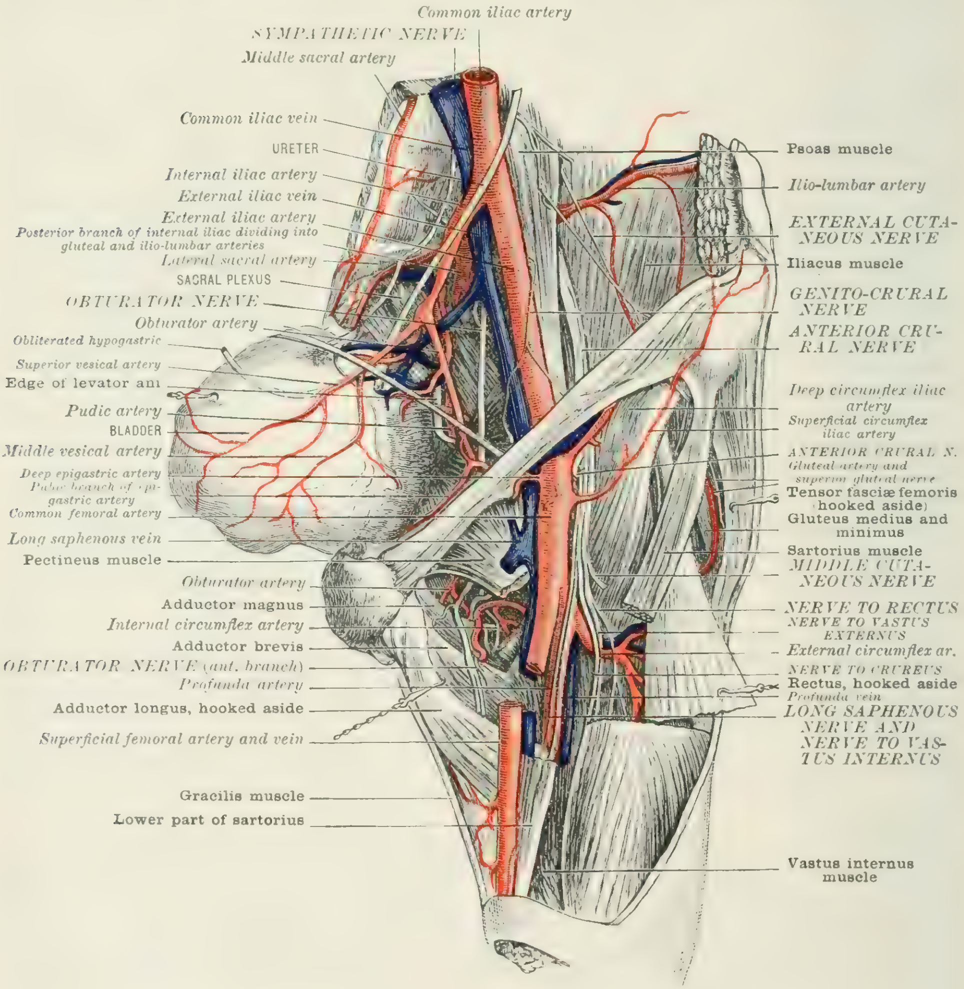
is superficial to it, but is separated from this part of the femoral artery by the deep fascia.

Behind, the artery lies on the pectineus, from which it is separated by the femoral vein and the profunda vein and artery. Lower down, it lies on the upper portion of the adductor longus muscle.

To its **outer side** is the long saphenous nerve and the nerve to the vastus internus, the anterior crural nerve having in this situation more or less broken up into its components.

FIG. 372.—THE FEMORAL ARTERY IN SCARPA'S TRIANGLE.

(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)


Common iliac artery
SYMPATHETIC NERVE
Middle sacral artery
Common iliac vein
URETER
Internal iliac artery
External iliac vein
External iliac artery
Posterior branch of internal iliac dividing into gluteal and ilio-lumbar arteries
Lateral sacral artery
SACRAL PLEXUS
OBTURATOR NERVE
Obturator artery
Obliterated hypogastric
Superior vesical artery
Edge of levator ani
Pudic artery
BLADDER
Middle vesical artery
Deep epigastric artery
Pubic branch of epigastric artery
Common femoral artery
Long saphenous vein
Pectineus muscle
Obturator artery
Adductor magnus
Internal circumflex artery
Adductor brevis
OBTURATOR NERVE (ant. branch)
Profunda artery
Adductor longus, hooked aside
Superficial femoral artery and vein
Gracilis muscle
Lower part of sartorius
Psoas muscle
Ilio-lumbar artery
EXTERNAL CUTANEOUS NERVE
Iliacus muscle
GENITO-CRURAL NERVE
ANTERIOR CRURAL NERVE
Deep circumflex iliac artery
Superficial circumflex iliac artery
ANTERIOR CRURAL N.
Gluteal artery and superior gluteal nerve
Tensor fasciæ femoris (hooked aside)
Gluteus medius and minimus
Sartorius muscle
MIDDLE CUTANEOUS NERVE
NERVE TO RECTUS
NERVE TO VASTUS EXTERNUS
External circumflex ar.
NERVE TO CRUREUS
Rectus, hooked aside
Profunda vein
LONG SAPHENOUS NERVE AND NERVE TO VASTUS INTERNUS
Vastus internus muscle

To its **inner side** is the femoral vein, which, however, at the apex of Scarpa's triangle, is getting somewhat behind the artery.

The superficial femoral varies in length according to the distance that the profunda is given off from the common femoral below Poupart's ligament. As a rule, it measures three inches and a half (9 cm.), the common an inch and a half (4 cm.). But the profunda may come off two or more inches below Poupart's ligament, in which case the superficial femoral will be shorter to this extent; or it may come off less than an inch and a half below Poupart's ligament, or even from the external iliac above Poupart's ligament, when the superficial will be longer than normal. The practical point to remember is that it is more usual to meet with a short than with a long common femoral, and that, if the superficial femoral is tied at the apex of Scarpa's triangle—i.e. the spot where the inner edge of the sartorius comes into contact with the adductor longus—there is nearly always a sufficient length of that vessel above the ligature to ensure a firm internal clot, and consequently, as far as this point is concerned, a successful result.

(3) **The relations of the superficial femoral artery in Hunter's canal.**—Hunter's canal is the somewhat triangularly shaped space bounded by the vastus internus on the outer side, the adductors longus and magnus on the inner side, and by an aponeurosis thrown across from the adductors to the vastus in front. Below, the canal terminates at the opening in the adductor magnus; above, its limit is less well defined, as here the aponeurosis between the muscles becomes less tendinous, and gradually fades away into the perimuscular fascia. The transverse direction of the fibres of the aponeurotic covering at the lower two-thirds of the canal is characteristic, and serves as a rallying point in tying the artery in this part of its course. Lying superficial to the aponeurosis is the sartorius muscle. The superficial femoral artery as it lies in this canal has the following relations:—

In front, in addition to the skin, superficial and deep fascia, are the sartorius muscle and the aponeurotic fibres of the canal. The internal saphenous nerve crosses the artery from without inwards, lying in the wall of the canal.

Behind is the angle of meeting of the vastus internus and the adductors.

The femoral vein lies behind the artery, but gets a little external to it at the lower part of the canal. It is here very firmly and closely attached to the artery, embracing it as it were on its posterior and external aspect. Hence it is very liable to be punctured on ligaturing the artery in this part of its course. Such an accident is best avoided by opening the sheath of the vessels well to the inner side of the front of the artery, and by keeping the point of the aneurysm needle closely applied to the vessel in passing it from without inwards between the vein and the artery. There are sometimes two veins, which then more or less surround the artery.

To its **inner side** is the adductor longus above and the adductor magnus below.

To its **outer side** is the vastus internus, the nerve to the vastus internus, and at the lower part of the canal the femoral vein.

Variations in the Femoral Artery

The most important variations in the femoral artery are:—(A) The femoral arising from the sciatic or internal iliac, and passing out of the pelvis and down the back of the thigh with the great sciatic nerve to the popliteal space; the external iliac under these circumstances ending in the profunda or external circumflex, or some other branch of the femoral. (B) A double condition of the femoral artery below the origin of the profunda; the vessel re-uniting lower down the thigh. (C) A vas aberrans given off from the inner side of the common femoral or external iliac, and joining the femoral lower down. (D) The vein may remain to the inner side of the artery its whole distance through the thigh, or it may be double, especially in Hunter's canal. There is often a plexiform arrangement of the vein around the artery in this situation. (E) The variations in the origin of the profunda have been already mentioned.

Branches of the Femoral Artery

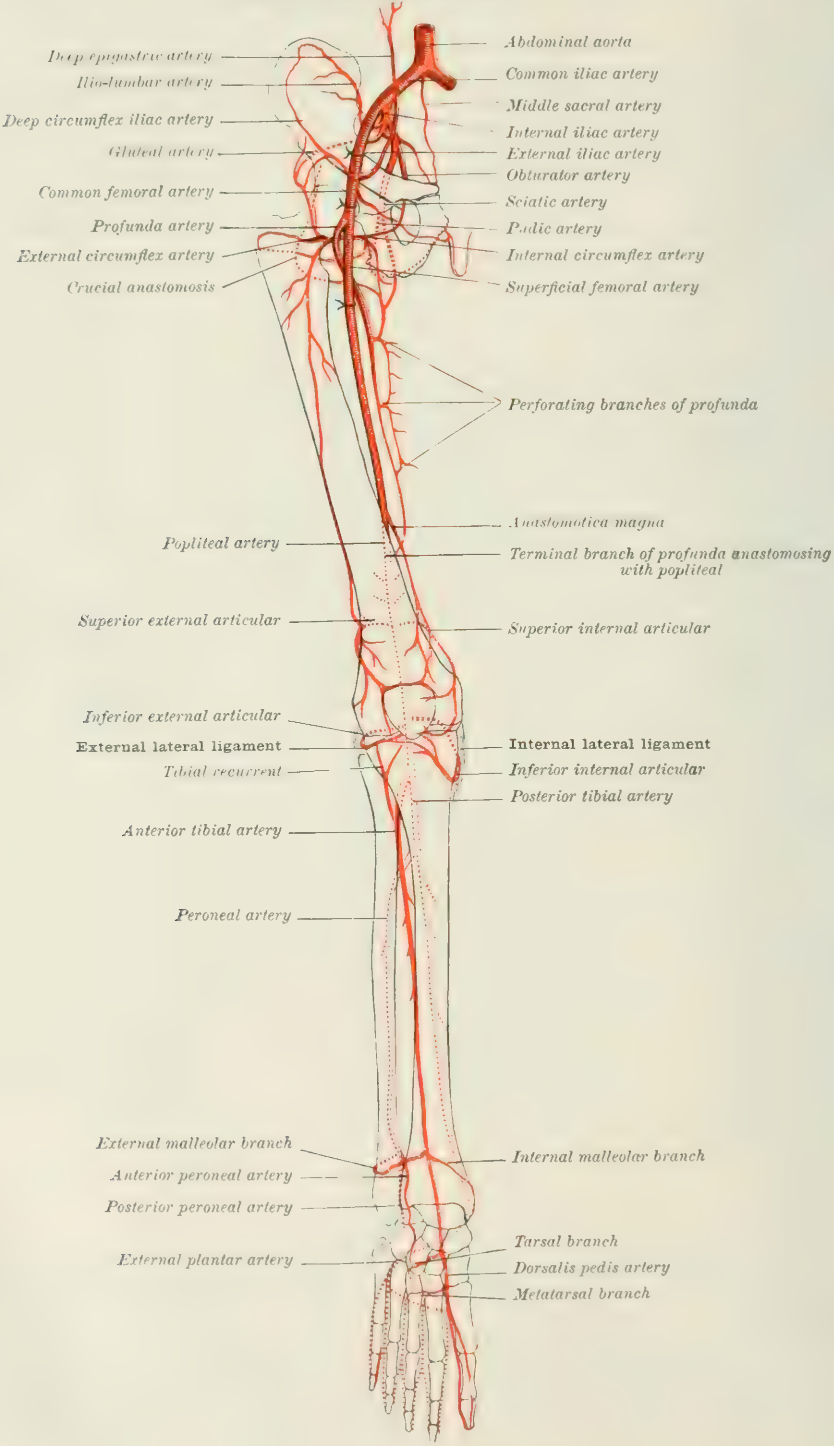
The femoral artery gives off the following branches:—

A. From the common femoral:—(1) The superficial epigastric; (2) the superficial circumflex iliac; (3) the superficial external pudic; (4) the deep external pudic; and (5) the profunda.

B. From the superficial femoral in Scarpa's triangle:—(1) Muscular branches; and (2) the saphenous branch.

C. From the superficial femoral in Hunter's canal:—(1) Muscular branches; and (2) the anastomotica magna.

FIG. 373.—TO SHOW THE ANASTOMOSES OF THE ARTERIES OF THE LOWER EXTREMITY. (After Smith and Walsham.)


Deep epigastric artery
Ilio-lumbar artery
Deep circumflex iliac artery
Gluteal artery
Common femoral artery
Profunda artery
External circumflex artery
Crucial anastomosis
Abdominal aorta
Common iliac artery
Middle sacral artery
Internal iliac artery
External iliac artery
Obturator artery
Sciatic artery
Pudic artery
Internal circumflex artery
Superficial femoral artery
Perforating branches of profunda
Anastomotica magna
Popliteal artery
Terminal branch of profunda anastomosing with popliteal
Superior external articular
Superior internal articular
Inferior external articular
External lateral ligament
Internal lateral ligament
Tibial recurrent
Inferior internal articular
Posterior tibial artery
Anterior tibial artery
Peroneal artery
External malleolar branch
Internal malleolar branch
Anterior peroneal artery
Posterior peroneal artery
Tarsal branch
External plantar artery
Dorsalis pedis artery
Metatarsal branch

A. *Branches of the Common Femoral*

(1) The **superficial epigastric artery** comes off from the femoral about half an inch below Poupart's ligament. At its origin it is beneath the fascia lata, but almost at once passes through this fascia, or else through the saphenous opening, and courses upwards and inwards in front of the external oblique muscle almost as far as the umbilicus. It ends in numerous small twigs, which anastomose with the cutaneous branches from the deep epigastric and internal mammary. In its course it gives off small branches to the inguinal glands and to the skin and superficial fasciæ. Running with it is the superficial epigastric vein, which ends in the long saphenous just before the latter passes through the saphenous opening.

(2) The **superficial circumflex iliac artery** (fig. 372), usually smaller than the superficial epigastric, arises either in common with that vessel, or else as a separate branch from the femoral. It passes upwards and outwards over the iliacus, and, soon perforating the fascia lata a little to the outer side of the saphenous opening, runs more or less parallel to Poupart's ligament about as far as the crest of the ilium, where it ends in branches which anastomose with the deep circumflex iliac artery. In its course it gives off branches to the iliacus and sartorius muscles, to the inguinal glands, and to the fascia and skin. Its companion vein, the superficial circumflex iliac, ends in the long saphenous vein just before the latter passes through the saphenous opening.

(3) The **superficial** or **superior external pudic artery** arises from the inner side of the femoral, either a little above or else in common with the deep or inferior external pudic. It passes either through the fascia lata, or else through the cribriform fascia covering the saphenous opening, ascends upwards and inwards over the spermatic cord in the male, or round ligament in the female, and divides into branches, one of which supplies the integuments above the pubes, while another descends along the penis external to the dorsal artery, with which, and with the corresponding artery of the opposite side, it anastomoses at the corona. In the female, this branch terminates in the preputium clitoridis, anastomosing with the dorsal artery of that organ. Small branches also descend to the scrotum and labium respectively. As it crosses the cord it anastomoses with the cremasteric branch of the deep epigastric. It is accompanied by two small veins, which usually join to form a single vein opening into the upper end of the long saphenous.

(4) The **deep** or **inferior external pudic artery** arises from the inner side of the femoral artery, either in common with the preceding branch or a little lower down. It runs inwards beneath the deep fascia, across the pectineus and adductor longus muscles, and, perforating the fascia close to the ramus of the pubes, supplies the skin of the scrotum or the corresponding part, the labium majus, in the female, anastomosing with the superficial perinæal branch of the internal pudic. It supplies small twigs to the pectineus and adductor muscles as it crosses them. Its companion veins terminate as a single trunk in the long saphenous.

(5) The **profunda** or **deep femoral artery** (figs. 372, 373) is the chief nutrient vessel of the thigh. It is usually given off from the back and outer part of the common femoral, about an inch and a half (4 cm.) below Poupart's ligament. At first it is a little external to the femoral, but as it runs downwards and backwards it gets behind that artery and closer to the bone. On reaching the upper border of the adductor longus muscle, it leaves the femoral, and, passing beneath the muscle, pierces the adductor magnus, and finally, much reduced in size, ends in the hamstring muscles.

Relations.—Behind, the artery lies successively upon the iliacus, the pectineus, the adductor brevis, and adductor magnus muscles. **In front,** at first it is superficial, being merely covered by the skin, superficial and deep fasciæ, and branches of the anterior crural nerve; but as it sinks behind the femoral artery, it has in front of it both the femoral and the profunda veins, and lower down the adductor longus muscle. **Externally** is the femur at the angle of union of the adductors longus and brevis. **Internally** is the pectineus at the upper part of its course.

Branches of the profunda.—The profunda gives off the following branches:—(*a*) The external circumflex; (*b*) the internal circumflex; and (*c*) the three perforating. The termination of the artery is sometimes called the fourth perforating branch.

(*a*) The **external circumflex,** a short trunk, but the largest in diameter of the branches of the artery, arises from the outer side of the profunda as it lies on the iliacus muscle, about three-quarters of an inch (2 cm.) below the origin of that vessel from the femoral. It passes transversely outwards over the iliacus, under the sartorius and rectus, and between the branches of the anterior crural nerve. In this course it gives off branches to the rectus and crureus, and then divides into three chief sets of branches—an ascending, transverse, and descending.

(i) The **ascending branch,** consisting of one or more separate vessels, runs upwards beneath the sartorius; then, sinking deeply beneath the tensor fasciæ femoris on the outer side, and the gluteus medius and minimus on the inner side, anastomoses with the superior gluteal and the deep circumflex iliac arteries. This branch also supplies a twig which runs upwards under the rectus to the hip-joint.

(ii) The **transverse branch,** or branches, run transversely outwards, and, winding over the crureus and piercing the vastus externus, anastomose towards the back of the thigh with the superior perforating branch of the profunda, the sciatic, and internal circumflex arteries. These branches will usually be found a little below the great trochanter.

(iii) The **descending branches** run directly downwards along with the nerve to the vastus externus muscle. They lie beneath the rectus muscle and on the crureus or vastus externus, some of them being just under cover of the anterior edge of the latter muscle. They are distributed to the vastus externus, crureus, and rectus, one branch usually running along the anterior border of the vastus externus as far as the knee-joint, where it anastomoses with the superior external articular branch of the popliteal (fig. 376); another, entering the crureus, anastomoses with the lower perforating branch of the profunda and with the anastomotica magna.

Variations of the external circumflex.—(A) It may come off from the femoral above the profunda. (B) It may be double, one branch coming off from the femoral, and one from the profunda, or both from the profunda, or both from the femoral above the profunda.

(*b*) The **internal circumflex artery** comes off from the back and inner part of the profunda artery on about the same level as the external circumflex; sometimes as a common trunk with that vessel. As it winds round the inner side of the femur to reach the region of the trochanters, it lies successively, first, between the psoas and pectineus, then between the obturator externus and adductor brevis; finally, between the adductor magnus and quadratus femoris, where it anastomoses with the external circumflex externally, with the sciatic above, and with the superior perforating below, forming the so-called **crucial anastomosis.** As it passes between the obturator externus and adductor brevis, it gives off two or more branches to the adductor longus, the adductor brevis, the gracilis, and the obturator externus, and anastomoses with the obturator artery. Another small branch usually courses upwards and outwards beneath the tendon of the psoas, and enters the hip-joint beneath the transverse ligament, and, together with the articular branch of the obturator, supplies the fatty tissue in the acetabulum, and sends branches to the synovial membrane. As it lies beneath the adductor brevis, it gives off a descending branch to the adductor magnus and brevis. This branch is generally accompanied by the posterior division of the obturator nerve. Before passing between the quadratus femoris and adductor magnus, a small branch runs upwards beneath the quadratus femoris to supply the back of the hip-joint, and anastomoses with the gluteal and sciatic arteries. Its companion veins join the profunda vein.

Variations of the internal circumflex.—(A) It may come off from the profunda artery before the external circumflex. (B) It may arise from the femoral artery; or (C) from the external iliac or one of its branches.

(*c*) The **perforating arteries of the profunda** are so called because they perforate, in a more or less regular manner from above downwards, certain of the adductor muscles. They form a series of loops by anastomosing with one another (fig. 373), and with the gluteal, internal circumflex, and sciatic arteries above, and with the muscular and articular branches of the popliteal below. They are distributed chiefly to the hamstring muscles, but send twigs along the external intermuscular septum to supply the integuments at the back and outer parts of the thigh. Other branches perforate the external intermuscular septum and the short head of the biceps, and, entering the crureus and vastus externus, anastomose with the descending branch of the external circumflex. All the perforating arteries, moreover, contribute to reinforce the artery of the sciatic nerve, a branch of the sciatic artery. They are each accompanied by two veins which terminate in the profunda.

(i) The **superior** or **first perforating** is given off from the profunda as that vessel sinks beneath the adductor longus. It either pierces the adductor brevis, or else runs between the pectineus and adductor brevis, and then passes through a small aponeurotic opening in the adductor magnus close to the inner lip of the linea aspera. In this course it supplies branches to the adductors, and, after perforating the adductor magnus, is distributed to the lower part of the gluteus maximus and the hamstring muscles, one branch commonly running upwards beneath the gluteus maximus to anastomose with the external circumflex, internal circumflex, and sciatic arteries, forming the **crucial anastomosis** at the junction of the neck of the femur with the great trochanter (fig. 373). A second branch descends to anastomose with the ascending branch of the middle perforating.

(ii) The **middle** or **second perforating**, which is given off from the profunda as it lies behind the adductor longus, pierces the adductor brevis, and then passes through a second aponeurotic opening in the adductor magnus a little below that for the first perforating artery, and also close to the linea aspera. It supplies the hamstring muscles, sends a branch upwards to anastomose with the descending branch of the superior perforating, and another downwards to anastomose in like manner with the ascending branch of the third perforating. It usually supplies the chief nutrient branch to the femur. At times, however, this comes from the third perforating.

(iii) The **inferior** or **third perforating** also arises from the profunda as it lies under the adductor longus, usually about the level of the lower border of the adductor brevis. It turns beneath this border, and then, like the first and second perforating, passes through an aponeurotic opening in the adductor magnus close to the linea aspera. It also supplies the hamstring muscles, and divides into two branches, which anastomose above with the second perforating, and below with the termination of the profunda or the fourth perforating.

(iv) The **fourth perforating** is the continuation of the profunda. It passes through an aponeurotic opening in the adductor magnus just above the opening for the femoral artery. It anastomoses, above with the third perforating, and below with the superior muscular and articular branches of the popliteal. It supplies chiefly the short head of the biceps.

B. *Branches of the Superficial Femoral in Scarpa's Triangle*

The branches given off by the superficial femoral in Scarpa's triangle are usually small and insignificant. They are:—(1) **Muscular,** to the sartorius and rectus; and (2) **saphenous,** to the region of the long saphenous vein and femoral lymphatics in the neighbourhood of the vein.

C. *Branches of the Superficial Femoral in Hunter's Canal*

The branches in Hunter's canal are:—(1) Muscular; and (2) the anastomotica magna.

(1) The **muscular branches** supply the sartorius, the rectus, the vastus internus, the crureus, and the adductor muscles. They are usually larger than the muscular branches given off in Scarpa's triangle.

(2) The **anastomotica magna** arises from the front and inner side of the

femoral just before the latter perforates the adductor magnus muscle, and almost immediately divides into two branches, (*a*) a superficial and (*b*) a deep. These branches may sometimes come off separately from the femoral.

(*a*) The **superficial branch** pierces the aponeurotic covering of Hunter's canal, passes between the sartorius and gracilis muscles along with the internal saphenous nerve, and, perforating the deep fascia, supplies the skin of the upper and inner side of the leg and anastomoses with the inferior internal articular branch of the popliteal and the other vessels forming the plexus or rete at the inner side of the knee. In its course it gives twigs to the lower part of the sartorius and gracilis muscles.

(*b*) The **deep branch** runs downwards in front of the adductor magnus tendon, burrowing amongst the fibres of the vastus internus as far as the internal condyle, where it passes into the plexus or rete on the inner side of the knee-joint, anastomosing with the internal inferior articular branch of the popliteal, the anterior tibial recurrent, and the external superior articular branch of the popliteal across the front of the femur just above the articular surface of the knee-joint. In common with the rest of the rete it sends branches into the knee-joint. It also supplies branches to the vastus internus and crureus muscles.

THE POPLITEAL ARTERY

The **popliteal artery** (fig. 375) runs through the popliteal space or ham. It is a continuation of the femoral, and extends from the aponeurotic opening in the adductor magnus at the junction of the middle with the lower third of the thigh to the lower border of the popliteus muscle, where it terminates by dividing into the posterior and anterior tibial arteries. This division is on a level with the lower border of the tubercle of the tibia. As the artery passes through the opening in the adductor magnus, it is accompanied by the popliteal vein, and at times by the branch of the obturator nerve to the knee-joint. The vein throughout is behind the artery, at first lying a little external to it, but as the vessels pass through the popliteal space the vein crosses obliquely over the artery, and at the termination of the artery lies a little to its inner side. The internal popliteal nerve is superficial to both artery and vein. As it enters the space it is well to the outer side of the vessels, but as it descends it gradually approaches them, crosses behind them, and at the lower part of the space lies to their inner side. The artery in the whole of its course is deeply placed and covered by a considerable amount of fat and cellular tissue.

Relations (fig. 374).—**In front,** the artery lies successively on the popliteal surface of the femur (from which it is separated by a little fat and sometimes one or two small glands); on the posterior ligament of the knee; on the hinder edge of the articular surface of the head of the tibia; and on the popliteus muscle. From the latter muscle it is separated by the expansion from the semi-membranosus which covers the muscle, and is attached to the oblique line on the tibia.

Behind, the artery is covered, above by the semi-membranosus; in the centre of the space by the skin, superficial and deep fascia; and below by the inner head of the gastrocnemius. The popliteal vein is behind it in the whole of its course. The internal popliteal nerve crosses behind it obliquely from without inwards, about the centre of the space. As the artery divides into the anterior and posterior tibial, it is crossed by the aponeurotic arch of the soleus which stretches between the tibial and fibular origins of that muscle.

To the **inner side** are the semi-membranosus above, and the inner head of the gastrocnemius and the internal popliteal nerve below.

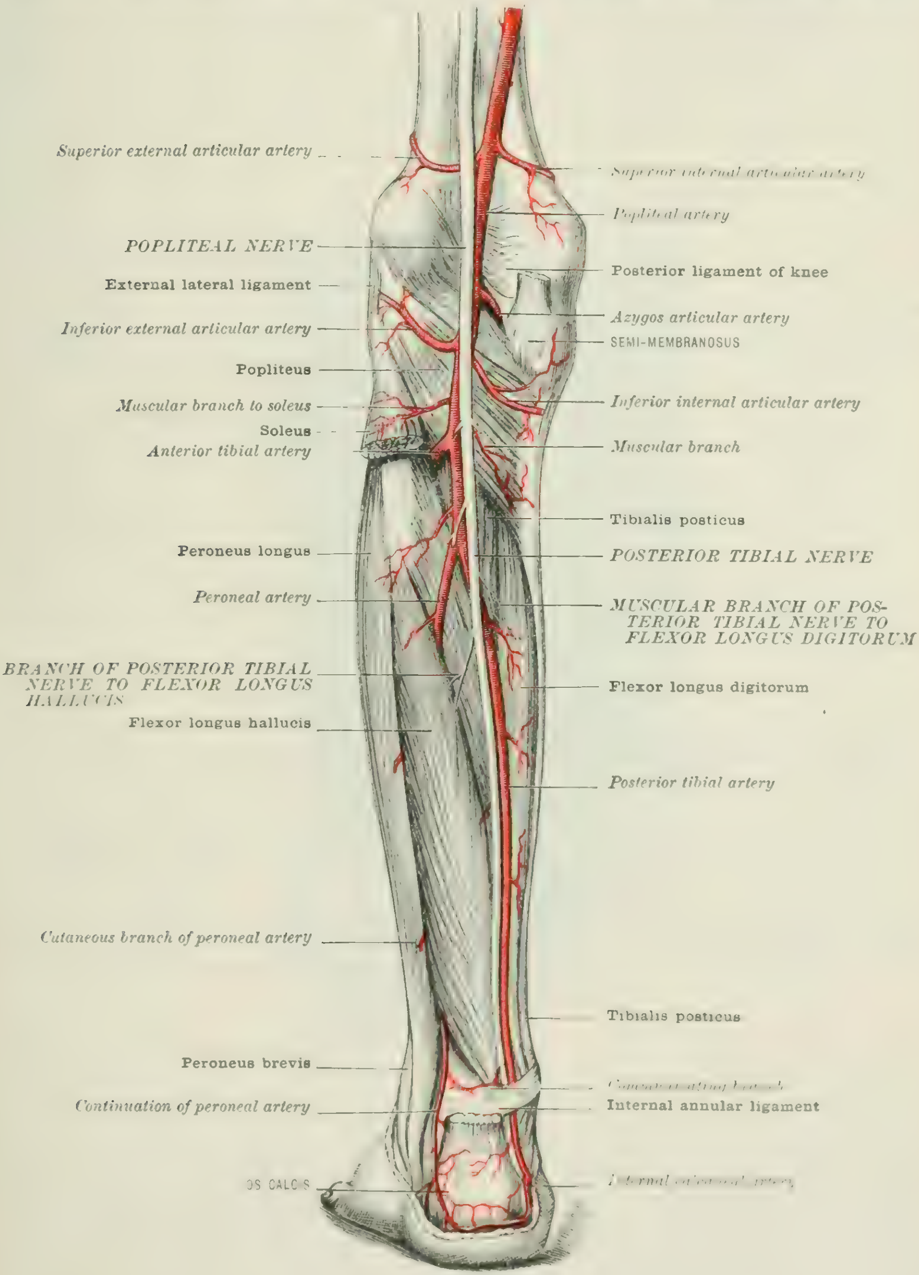
To the **outer side** are the biceps and the internal popliteal nerve above, and the outer head of the gastrocnemius and the plantaris below.

Principal variations in the popliteal.—(A) It may divide higher, or more rarely lower than usual. (B) It may divide into the anterior tibial and peroneal. (C) The vein may be deeper than the artery, or separated from it by a slip of the gastrocnemius.

BRANCHES OF THE POPLITEAL ARTERY

The branches of the popliteal may be divided into—(1) The cutaneous; (2) the muscular or sural; (3) the articular; and (4) the terminal.

FIG. 374.—RELATIONS OF THE POPLITEAL ARTERY TO BONES AND MUSCLES. LEFT SIDE.


Superior external articular artery
Superior internal articular artery
Popliteal artery
POPLITEAL NERVE
External lateral ligament
Posterior ligament of knee
Azygos articular artery
Inferior external articular artery
SEMI-MEMBRANOSUS
Popliteus
Muscular branch to soleus
Inferior internal articular artery
Soleus
Anterior tibial artery
Muscular branch
Tibialis posticus
Peroneus longus
POSTERIOR TIBIAL NERVE
Peroneal artery
MUSCULAR BRANCH OF POSTERIOR TIBIAL NERVE TO FLEXOR LONGUS DIGITORUM
BRANCH OF POSTERIOR TIBIAL NERVE TO FLEXOR LONGUS HALLUCIS
Flexor longus digitorum
Flexor longus hallucis
Posterior tibial artery
Cutaneous branch of peroneal artery
Tibialis posticus
Peroneus brevis
Communicating branch
Continuation of peroneal artery
Internal annular ligament
OS CALCIS
Internal calcanean artery

(1) The **cutaneous branches**—very irregular in their origin, number, and distribution—arise either from the main trunk or from one of the inferior muscular branches, pass downwards between the two heads of the gastrocnemius, and, per-

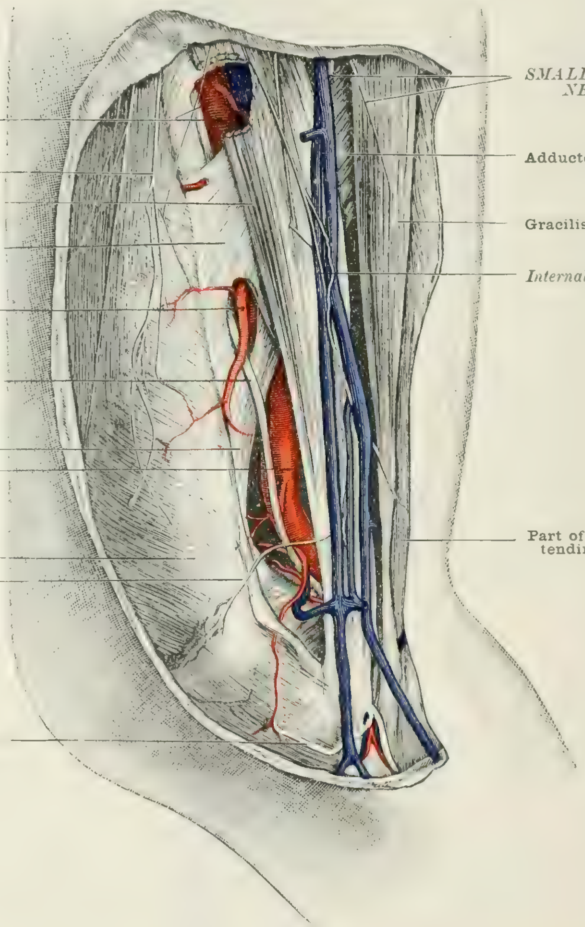
forating the deep fascia, supply the skin and fascia of the calf. A branch, usually of moderate size, accompanies the short or external saphenous vein, and is sometimes called the posterior saphenous artery.

(2) The **muscular** or **sural branches** are commonly divided into the superior and inferior. They arise from the upper and lower portions of the popliteal respectively; the former supply the muscles forming the boundaries of the upper half of the popliteal space; the latter, the muscles of the calf.

(*a*) The **upper muscular branches**—or **superior sural**, as they are sometimes called—are distributed to the hamstring muscles and lower part of the adductor magnus. They anastomose with the superior articular arteries, and with the termination of the profunda. (*b*) The **inferior muscular** or **sural branches**, usually two in number and of large size, come off from the popliteal just as it passes under cover of the inner head of the gastrocnemius. They at first descend between the two heads of the latter muscle, one branch then entering the outer, and one the inner head. They also supply branches to the soleus and plantaris muscles.

FIG. 375.—SIDE VIEW OF THE RIGHT POPLITEAL ARTERY.

(From a dissection in the Hunterian Museum.)

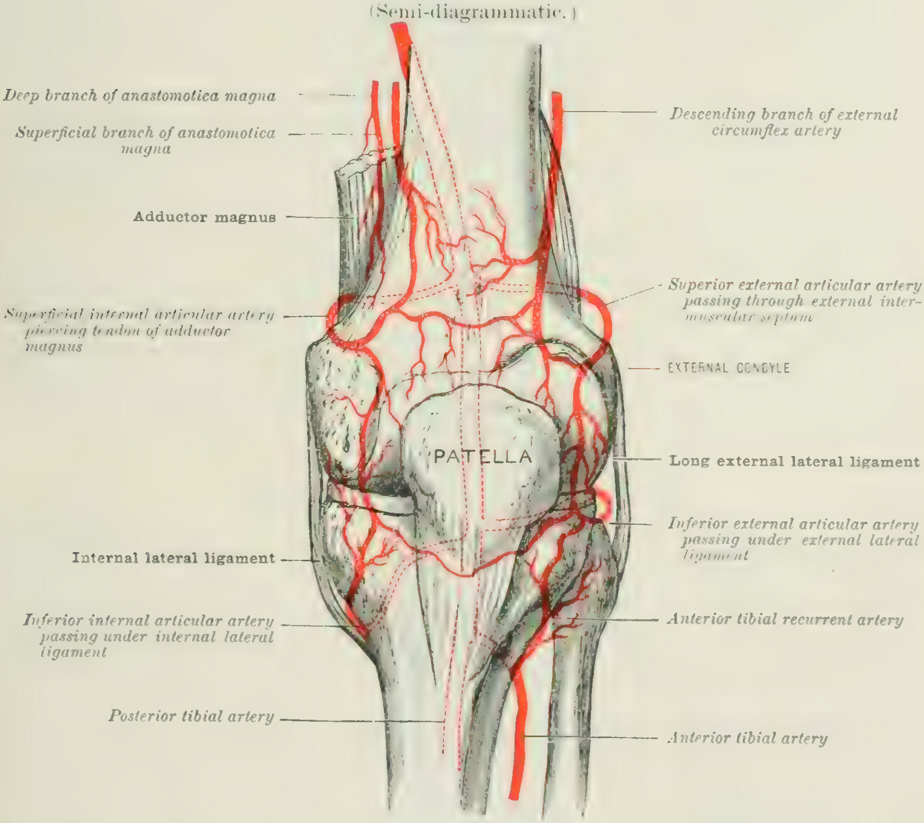

Femoral artery and vein
BRANCHES OF THE INTERNAL CUTANEOUS NERVE
Sartorius
Aponeurotic covering of Hunter's canal
Anastomotica magna artery
LONG SAPHENOUS NERVE
Vertical fibers of the adductor magnus
Popliteal artery
Vastus internus
Cut edge of fascia lata
BRANCH OF SAPHENOUS NERVE TO PATELLAR PLEXUS
SMALL SCIATIC NERVE
Adductor magnus
Gracilis
Internal saphenous vein
Part of semi-tendinosus

(3) The **articular**, five in number, are divided into two superior (internal and external), two inferior (internal and external), and the azygos, or anterior. The superior and inferior come off transversely in pairs from either side of the popliteal,

the superior above, the inferior below the joint, and, winding round the bones to the front of the knee, form—by anastomosing with each other and with the anastomotica magna, the termination of the profunda, the descending branch of the external circumflex, and the anterior tibial recurrent—a superficial and deep arterial rete (fig. 376). The superficial anastomosis or rete lies between the skin and fascia round about the patella (**patellar rete**), which it supplies, the larger branches entering it from above. The deep anastomosis or rete lies on the surface of the bones around the articular surfaces of the femur and tibia, supplying branches to the contiguous bones and to the joints. The azygos articular is a single short trunk coming off from the deep surface of the popliteal artery. It at once passes through the posterior ligament into the joint.

(*a*) The **superior external articular**, the larger of the two superior articular branches, runs transversely outwards above the external head of the gastrocnemius, and, passing beneath the biceps and through the external intermuscular septum and vastus externus, enters the substance of the crureus, and anastomoses, above with the descending branch of the external circumflex, below with the inferior external articular, and across the front of the femur with the superior internal articular, the anastomotica magna, and termination of the profunda, forming with them, as already described, the deep periarticular rete. Branches are given off to the patella, to the upper and outer part of the joint, to the bone, and to the contiguous muscles.

FIG. 376.—THE ANASTOMOSIS ABOUT THE LEFT KNEE-JOINT. (Walsham.)



(Semi-diagrammatic.)

Deep branch of anastomotica magna
Superficial branch of anastomotica magna
Adductor magnus
Superficial internal articular artery piercing tendon of adductor magnus
Internal lateral ligament
Inferior internal articular artery passing under internal lateral ligament
Posterior tibial artery
Descending branch of external circumflex artery
Superior external articular artery passing through external intermuscular septum
EXTERNAL CONDYLE
PATELLA
Long external lateral ligament
Inferior external articular artery passing under external lateral ligament
Anterior tibial recurrent artery
Anterior tibial artery

(*b*) The **superior internal articular** (fig. 374) runs transversely inwards just above the inner head of the gastrocnemius, beneath the semi-membranosus, and, after perforating the tendon of the adductor magnus, enters the substance of the vastus internus, where it anastomoses (fig. 376) with the deep branch of the anastomotica magna and termination of the profunda above, with the inferior internal articular below, and with the superior external articular across the front of the femur. It supplies small branches to the contiguous muscles, to the femur, to the patella, and to the joint.

(*c*) The **inferior internal articular,** the larger of the two inferior articular arteries, passes obliquely downwards and inwards across the popliteus, below the internal tuberosity of the tibia, and beneath the internal lateral ligament to the front and inner side of the knee-joint, where it anastomoses (fig. 376), above with the superior internal articular and the superficial branch of the anastomotica magna, and across the front of the tibia with the inferior external articular. It supplies branches to the lower and inner part of the joint.

(*d*) The **inferior external articular** (fig. 376) passes outwards above the head of the fibula, along the tendon of the popliteus muscle, beneath the external head of the gastrocnemius, and then under the tendon of the biceps, and between the long and short external lateral ligaments. Then winding to the front of the joint, it anastomoses above with the superior external articular, below with the anterior tibial recurrent, and across the front of the tibia with the internal inferior articular. It also supplies branches to the outer and lower part of the joint.

(*e*) The **azygos articular** arises from the deep surface of the popliteal artery, and passes, with the articular branch of the obturator nerve, through the posterior ligament, directly into the knee-joint, where it supplies the crucial ligaments, and the ligamenta mucosa and alaria. It anastomoses with the intrinsic branches of the other articular arteries.

(4) The **terminal branches** of the popliteal are the posterior and anterior tibial arteries. The former appears to be a direct continuation of the vessel, and passes down the back of the leg to the inner ankle, where, on entering the sole of the foot, it divides into the internal and external plantar. The anterior tibial turns forwards, and, passing through the interosseous membrane, descends along the front of the leg, and ends, under the name of the dorsal artery of the foot, by anastomosing, through the first interosseous space, with the external plantar artery in the sole.

THE POSTERIOR TIBIAL ARTERY

The **posterior tibial artery** (fig. 377), the larger of the two branches into which the popliteal divides at the lower border of the popliteus muscle, runs downwards on the flexor aspect of the leg between the superficial and deep muscles to the back of the inner ankle, where, midway between the tip of the internal malleolus and os calcis, and under cover of the origin of the abductor hallucis as it arises from the internal annular ligament, it divides into the internal and external plantar arteries.

The artery is first situated midway between the tibia and fibula, and is deeply placed beneath the muscles of the calf. As it passes downwards it inclines inwards, and at the lower third of the leg is superficial, being only covered by the skin and fasciæ. At the ankle it lies beneath the internal annular ligament, and at its bifurcation also beneath the abductor hallucis. A line drawn from the centre of the popliteal space to a spot midway between the internal malleolus and point of the heel will indicate its course.

Relations.—**Anteriorly,** from above downwards, it lies successively on the tibialis posticus, the flexor longus digitorum, the posterior surface of the tibia, and the internal lateral ligament of the ankle-joint.

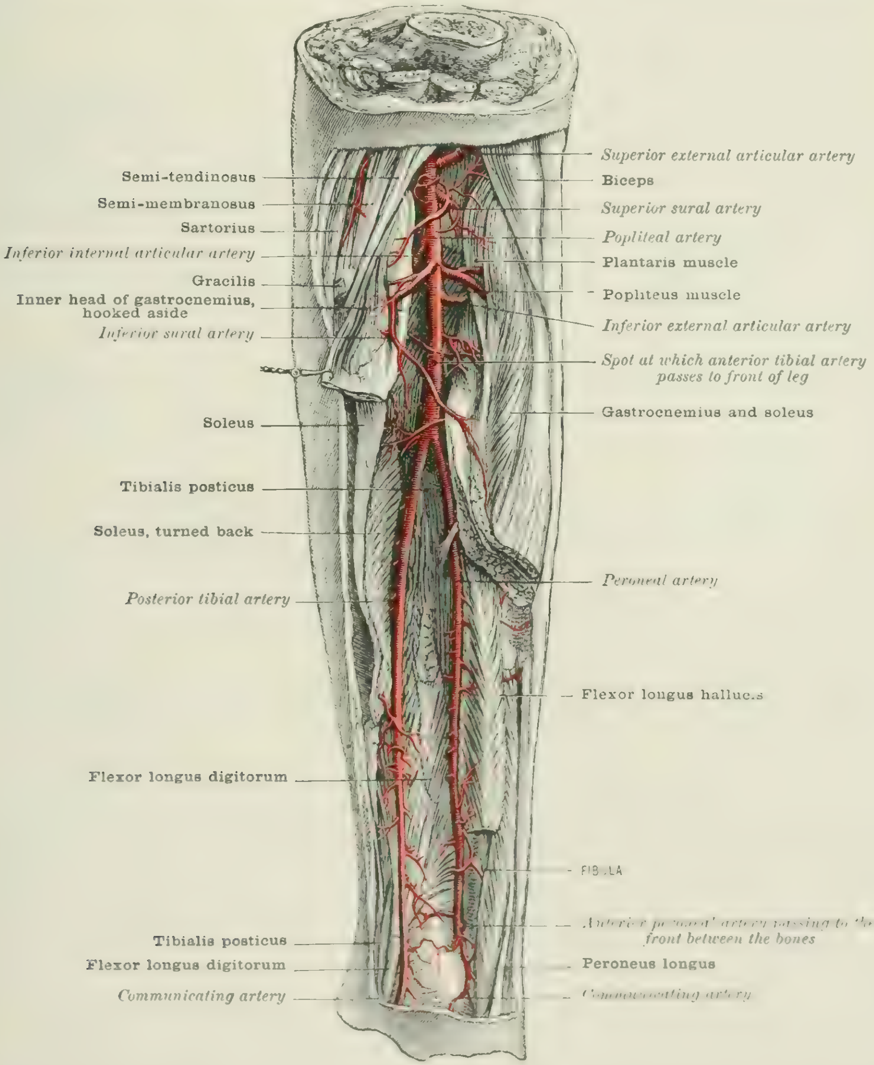
Posteriorly, it is covered by the skin and fascia, the gastrocnemius and soleus, and the deep or intermuscular fascia of the leg, by which it is tightly bound down to the underlying muscles. It is crossed by the posterior tibial nerve about an inch and a half below its origin and after it has given off its peroneal branch, the nerve first being on the inner, and for the rest of its course on the outer side of the vessel (fig. 374). It is accompanied by two veins, which send numerous anastomosing branches across it. In the lower third of the leg the artery is superficial, being only covered by the skin and by the superficial and deep fasciæ.

At the **inner ankle** it lies beneath the internal annular ligament and abductor hallucis upon the internal lateral ligament of the ankle-joint. Here it has the tibialis posticus and flexor longus digitorum in front of it, and the posterior tibial nerve and the flexor longus hallucis behind and to its outer side.

At times the posterior tibial nerve divides higher than usual, when one branch lies on the inner side of the artery, and the other branch on the outer side.

The **branches of the posterior tibial artery** are:—(1) The peroneal; (2) the muscular; (3) the medullary; (4) the cutaneous; (5) the communicating; (6) the malleolar; (7) the calcanean, or internal calcanean; and (8) the terminal, i.e. the external and internal plantar arteries.

FIG. 377.—THE POPLITEAL, THE POSTERIOR TIBIAL, AND THE PERONEAL ARTERY. RIGHT SIDE.


Superior external articular artery
Biceps
Superior sural artery
Popliteal artery
Plantaris muscle
Popliteus muscle
Inferior external articular artery
Spot at which anterior tibial artery passes to front of leg
Gastrocnemius and soleus
Peroneal artery
Flexor longus hallucis
FIBULA
Anterior peroneal artery passing to the front between the bones
Peroneus longus
Communicating artery
Semi-tendinosus
Semi-membranosus
Sartorius
Inferior internal articular artery
Gracilis
Inner head of gastrocnemius, hooked aside
Inferior sural artery
Soleus
Tibialis posticus
Soleus, turned back
Posterior tibial artery
Flexor longus digitorum
Tibialis posticus
Flexor longus digitorum
Communicating artery

(1) The **peroneal artery** (figs. 374, 377) arises from the posterior tibial about one inch below the lower border of the popliteus muscle. At first forming a gentle curve with the convexity outwards, it approaches the fibula, and continues its course downwards close to that bone as far as the lower end of the interosseous membrane,

where it gives off a large branch, the anterior peroneal, and then, passing over the back of the inferior tibio-fibular joint, terminates by breaking up into a network, which is distributed over the back of the external malleolus and outer surface of the calcaneum (fig. 381). It is accompanied by two venæ comites.

Relations.—At its upper part it is deeply placed between the tibialis posticus and soleus muscles, and beneath the deep or intermuscular fascia. For the rest of its course to the ankle it lies beneath, or sometimes in the substance of the flexor longus hallucis in the angle between the fibula and interosseous membrane. After giving off the anterior peroneal, it is only covered, as it lies behind the tibio-fibular articulation, by the integuments and deep fascia, and in this part of its course is sometimes called the **posterior peroneal.**

The **branches of the peroneal artery** are:—(*a*) The anterior peroneal; (*b*) the muscular; (*c*) the medullary; (*d*) the communicating; (*e*) the cutaneous; (*f*) the external calcanean; and (*g*) the terminal.

(*a*) The **anterior peroneal artery** arises from the front of the peroneal artery at the lower part of the interosseous space, and, passing through the interosseous membrane, runs downwards over the front of the inferior tibio-fibular joint, beneath the peroneus tertius, and supplies this muscle and the inferior tibio-fibular joint. It anastomoses with the tarsal, metatarsal, and external malleolar branches of the anterior tibial artery, and with the external plantar artery on the outer side of the foot, forming a plexus over the outer ankle (fig. 380).

(*b*) The **muscular branches** of the peroneal artery are distributed to the contiguous muscles, namely: the flexor longus hallucis, the tibialis posticus, the peronei, and the soleus.

(*c*) The **medullary** enters the nutrient foramen of the fibula.

(*d*) The **communicating branches** pass transversely inwards in front of the tendo Achillis to anastomose with the communicating branch of the posterior tibial. The usual situation of this communication is from one to two inches above the ankle-joint.

(*e*) The **cutaneous branches** run outwards between the flexor longus hallucis and soleus to supply the integuments on the outer side of the leg.

(*f*) The **external calcanean** comes off from the peroneal below the point at which the anterior peroneal is given off, and is distributed over the outer surface of the os calcis.

(*g*) The **terminal branch** or **posterior peroneal,** the continuation of the peroneal artery, anastomoses with the other arteries distributed to the external malleolus and heel.

(2) The **muscular branches** of the posterior tibial artery are distributed to the contiguous muscles, namely: the tibialis posticus, flexor longus digitorum, and soleus.

(3) The **medullary artery,** a vessel of large size, leaves the posterior tibial at its upper part, pierces the tibialis posticus, and enters the medullary foramen in the upper third of the posterior surface of the tibia. In the interior of the bone it divides into two branches: an ascending or smaller, which runs upwards towards the head of the bone; and a descending or larger, which courses downwards towards the lower end. It gives off two or three muscular twigs to the tibialis posticus before it enters the foramen. The medullary artery of the tibia is the largest nutrient artery of bone in the body, and is accompanied by a nerve given off by the nerve to the popliteus.

(4) The **cutaneous branches** pass inwards to the integuments on the inner side of the leg. They run in the cellular planes between the deep and superficial muscles, and serve as useful guides to the vessel when ligaturing the posterior tibial through the lateral incision.

(5) The **communicating branch** arises from the posterior tibial about two inches above the inner malleolus, and, passing transversely outwards across the tibia beneath the flexor longus hallucis and tendo Achillis, anastomoses with the communicating branch of the peroneal.

Frequently an inferior communicating branch between the posterior tibial and peroneal arteries is likewise present in the loose connective tissue beneath or behind the tendo Achillis (fig. 374).

(6) The **malleolar** or **internal malleolar branches** are distributed, as the name implies, over the internal malleolus, anastomosing with the other arteries entering into the retiform plexus of vessels over that portion of bone. In their course to the malleolus, they run beneath the flexor longus digitorum and tibialis posticus muscles.

(7) The **calcanean** or **internal calcanean branch** is distributed to the soft parts over the inner side of the calcaneum. This branch—or, as is frequently the case, branches—comes off from the posterior tibial just before its bifurcation, and anastomoses with the internal malleolar and peroneal arteries (fig. 379).

(8) The **terminal branches** are the external and internal plantar arteries.

THE EXTERNAL PLANTAR ARTERY

The **external plantar artery**—the larger of the two branches into which the posterior tibial divides beneath the internal annular ligament—passes at first obliquely forwards and outwards across the sole of the foot to the base of the fifth metatarsal bone, where it makes a bend forwards and inwards, and, sinking deeply into the foot, terminates at the proximal end of the first interosseous space by anastomosing with the communicating branch of the dorsal artery of the foot. In its course to the fifth metatarsal bone the artery runs in a more or less straight line obliquely across the foot; whilst its deep portion, extending from the fifth metatarsal bone to the proximal end of the first interosseous space, forms a slight curve with the convexity forwards, and is known as the **plantar arch.** The plantar arch is comparable to the deep palmar arch formed by the deep branch of the ulnar anastomosing with the radial through the first interosseous space. This homology is at times more complete in that the communicating branch of the dorsalis pedis, the homologue of the radial in the upper limb, takes the chief share in forming the arch. The external plantar artery is accompanied by two veins. The course of the artery is indicated by a line drawn across the sole of the foot from a point midway between the tip of the internal malleolus and the greater tubercle of the calcaneum to the base of the fifth metatarsal bone, and thence forwards and inwards to the posterior part of the ball of the great toe.

Relations.—In the **first part of its course** from the inner ankle to the base of the fifth metatarsal bone, the artery is covered successively by the abductor hallucis and the flexor brevis digitorum, by which it is separated from the plantar fascia, and may be slightly overlapped in muscular subjects by the abductor minimi digiti. As it approaches the base of the fifth metatarsal bone, it lies, as it turns forwards and inwards before sinking into the foot, in the interspace between the flexor brevis digitorum and the abductor minimi digiti, and is here only covered by the skin and superficial fascia, and the plantar fascia. It lies upon the calcaneum, the flexor accessorius, and the flexor brevis minimi digiti. It is accompanied by the external plantar nerve, the smaller of the two divisions into which the posterior tibial nerve divides. In this part of its course it gives off small branches to the contiguous muscles and to the heel.

In the **second part of its course** the artery, which is here known as the plantar arch, sinks into the sole, and is covered, in addition to the skin, superficial fascia, plantar fascia, and flexor brevis digitorum, by the tendon of the flexor longus digitorum, the lumbricales, branches of the internal plantar nerve, and the adductor hallucis. It lies upon the proximal ends of the second, third, and fourth metatarsal bones and the corresponding interosseous muscles.

The **branches of the external plantar artery** are:—(1) Muscular; (2) calcaneal; (3) cutaneous; (4) anastomotic; (5) articular; (6) posterior perforating; and (7) digital.

(1) The **muscular branches** of the external plantar are distributed to the contiguous muscles; in the first part of its course to the flexor brevis digitorum, and the accessorius; as it makes its bend into the sole, to the muscles of the little toe; and, as it forms the plantar arch, to the interossei, flexor brevis hallucis, and adductor hallucis.

(2) The **calcanean** are two or three small branches which are distributed over

the inner surface of the calcaneum, and anastomose with the internal calcanean branch of the posterior tibial artery (fig. 379).

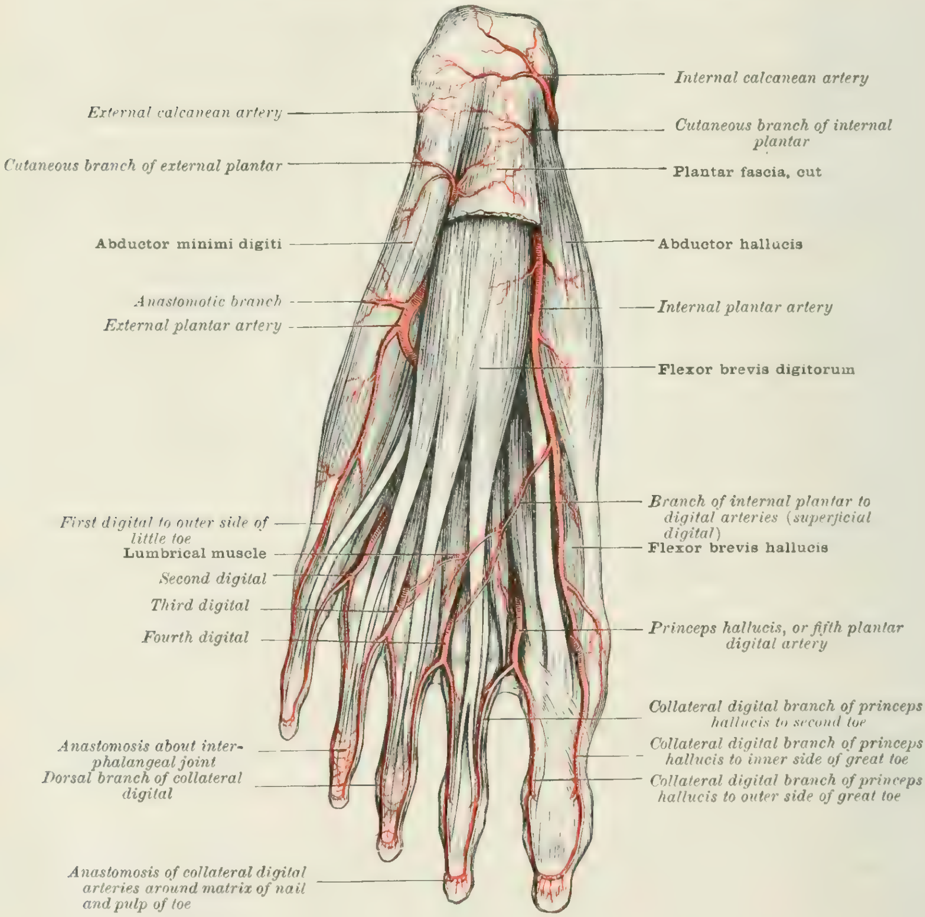
(3) The **cutaneous** pass between the abductor minimi digiti and flexor brevis digitorum, and through the interval between the middle and outer portions of the plantar fascia, to the skin.

(4) The **anastomotic** turn over the outer border of the foot, and anastomose with the tarsal and metatarsal branches of the dorsalis pedis (fig. 381).

(5) The **articular** come off from the concavity of the arch, and, running backwards and upwards, are distributed to the articulations of the tarsus. They are homologous to the recurrent branches of the deep palmar arch in the hand, and, like the latter, are usually three in number.

FIG. 378.—THE PLANTAR ARTERIES, LEFT FOOT.

(From a dissection in the Museum of St. Bartholomew's Hospital.)

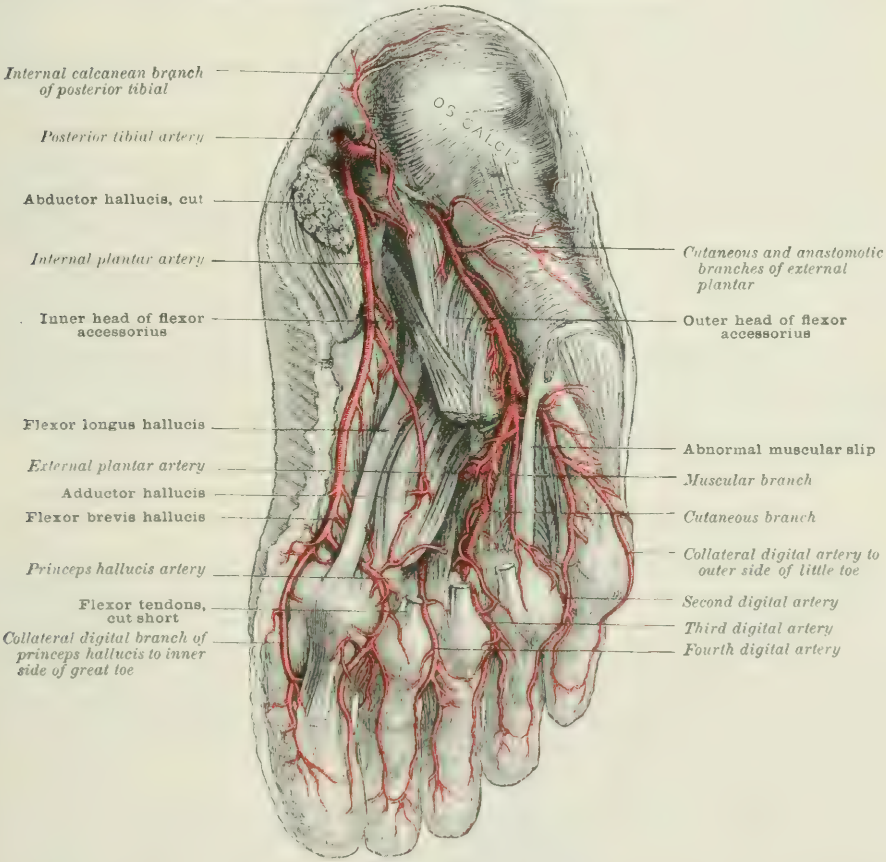

Internal calcanean artery
External calcanean artery
Cutaneous branch of internal plantar
Cutaneous branch of external plantar
Plantar fascia, cut
Abductor minimi digiti
Abductor hallucis
Anastomotic branch
Internal plantar artery
External plantar artery
Flexor brevis digitorum
Branch of internal plantar to digital arteries (superficial digital)
First digital to outer side of little toe
Lumbrical muscle
Flexor brevis hallucis
Second digital
Third digital
Fourth digital
Princeps hallucis, or fifth plantar digital artery
Collateral digital branch of princeps hallucis to second toe
Anastomosis about inter-phalangeal joint
Collateral digital branch of princeps hallucis to inner side of great toe
Dorsal branch of collateral digital
Collateral digital branch of princeps hallucis to outer side of great toe
Anastomosis of collateral digital arteries around matrix of nail and pulp of toe

(6) The **posterior perforating,** also three in number, ascend through the proximal end of the second, third, and fourth spaces, between the two heads of the correspondingly named dorsal interosseous muscles, and communicate with the proximal ends of the first, second, and third interosseous arteries (fig. 381).

(7) The **digital** or **plantar digital arteries** are usually four in number, and are distributed to the inner and outer sides of the third, fourth, and fifth toes, and to the outer side of the second toe. They are named first, second, third, and fourth as they come off from the arch from without inwards, and not according to

the interosseous space in which they run. The first comes off from the outermost part of the plantar arch, and courses forwards along the outer side of the little toe (figs. 378, 379, 381), over the fifth metatarsal bone and the abductor and flexor brevis minimi digiti muscles. The second, third, and fourth digitals run forwards in the centre of the interosseous spaces on the therein contained interosseous muscles, under cover of the contiguous lumbrical, the short and long flexor tendons, and the transversalis pedis muscle. Near the cleft of the toes they become superficial, and bifurcate for the supply of the contiguous sides of the toes: the second supplying the inner side of the fifth and the outer side of the fourth toe; the third the inner side of the fourth and the outer side of the third toe; and the fourth the inner side of the third and the outer side of the second toe. The supply of the inner side of the second and both sides of the great toe is derived from the dorsalis pedis through its communicating branch to the plantar arch. The digital arteries, immediately before they bifurcate, send upwards on to the dorsum of the foot a communicating branch (the anterior perforating artery) to the corresponding dorsal interosseous arteries. On the side of the toes the digital arteries—here sometimes called the **collateral digital arteries**—furnish numerous small branches to the integuments and the flexor tendons and their sheaths. They anastomose by many small twigs with the dorsal interosseous arteries, which also run along the sides of the toes, but more towards the dorsal aspect. Immediately above each phalangeal joint the collateral digital vessels communicate by cross branches, forming a rete for the supply of the articular end of the phalanges and the con-

FIG. 379.—RIGHT PLANTAR ARTERIES (DEEP).
(From a dissection in the Hunterian Museum.)


Internal calcanean branch of posterior tibial
Posterior tibial artery
Abductor hallucis, cut
Internal plantar artery
Inner head of flexor accessorius
Flexor longus hallucis
External plantar artery
Adductor hallucis
Flexor brevis hallucis
Princeps hallucis artery
Flexor tendons, cut short
Collateral digital branch of princeps hallucis to inner side of great toe
OS CALCIS
Cutaneous and anastomotic branches of external plantar
Outer head of flexor accessorius
Abnormal muscular slip
Muscular branch
Cutaneous branch
Collateral digital artery to outer side of little toe
Second digital artery
Third digital artery
Fourth digital artery

tiguous joints. At the distal end of the toes they also freely anastomose with each other, forming a rete beneath the pulp and around the matrix of the nail. The digital arteries are each accompanied by two small veins.

THE INTERNAL PLANTAR ARTERY

The **internal plantar artery** (figs. 378, 379)—the smaller of the two divisions into which the posterior tibial divides at the inner ankle—passes forwards along the inner side of the sole of the foot usually to the first interosseous space, where it ends by anastomosing either with the fifth plantar digital artery (princeps hallucis) derived from the communicating branch of the dorsalis pedis, or with the branch given off by the fifth plantar digital to the inner side of the great toe (figs. 378, 379).

Relations.—The artery is at first under cover of the abductor hallucis, but afterwards lies in the interval between that muscle and the flexor brevis digitorum. It is covered by the skin and superficial fascia, but not by the plantar fascia, since it lies between the middle and inner portions of that structure.

The branches of the internal plantar are small and irregular in their origin, course, and distribution. The following are described:—

(1) The **muscular branches** supply the abductor hallucis, and flexor brevis digitorum.

(2) The **cutaneous branches** supply the skin over the course of the vessel.

(3) The **articular** sink deeply into the sole, and supply the articulations on the inner side of the foot, and anastomose with branches of the external plantar artery.

(4) The **anastomotic** run beneath the abductor hallucis and round the inner side of the foot, to anastomose with the internal tarsal branch of the dorsalis pedis.

(5) The **superficial digital** are very small twigs which accompany the digital branches of the internal plantar nerves, and anastomose with the plantar digital arteries in the first, second, and third spaces. At times a twig from one of these branches joins the external plantar artery to form a superficial plantar arch.

THE ANTERIOR TIBIAL ARTERY

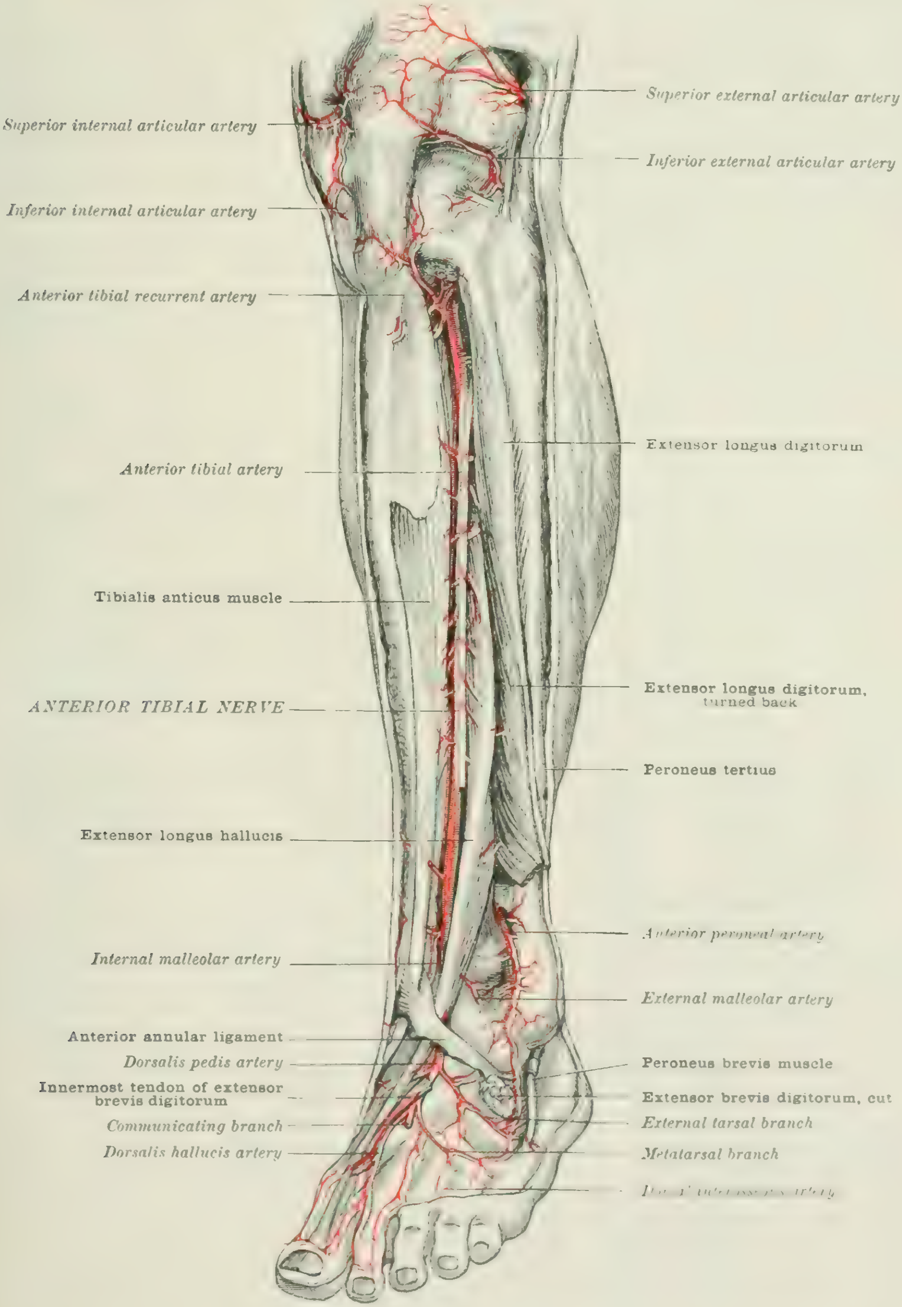
The **anterior tibial artery** (fig. 380)—the smaller of the two branches into which the popliteal artery divides at the lower border of the popliteus muscle—at first courses forwards between the two heads of origin of the tibialis posticus, and, after passing between the tibia and fibula above the upper part of the interosseous membrane, runs downwards on the front and outer aspect of the leg, between the anterior muscles, as far as the front of the ankle-joint (fig. 380). Below this spot it is known as the dorsalis pedis. The **course of the vessel** is indicated by a line drawn from the front of the head of the fibula to a point midway between the two malleoli.

The artery is accompanied by two veins which communicate with each other at frequent intervals across it. It is also accompanied in the lower three-fourths of its course by the anterior tibial nerve. The nerve, which winds round the head of the fibula, and pierces the extensor longus digitorum, first comes into contact with the outer side of the artery somewhere about the upper third of the leg; then, in the middle third of the leg, it gets a little in front of the artery, and in the lower third again lies to its outer side.

Relations.—The artery at first lies in the triangle formed by the two heads of the tibialis posticus and the popliteus muscle; and, as it passes through the hole in the interosseous membrane, it has the tibia on one side and the fibula on the other. It is separated from the anterior tibial nerve at its commencement by the neck of the fibula and the extensor longus digitorum. This arrangement is homologous with that met with in the forearm in the case of the posterior interosseous artery and nerve.

Posteriorly in its course down the leg it lies in its upper two-thirds upon the interosseous membrane, to which it is closely bound by fibrous bands; and in its lower third upon the front of the tibia and the ankle-joint.

FIG. 380.—THE ANTERIOR TIBIAL ARTERY, DORSAL ARTERY OF THE FOOT, AND ANTERIOR PERONEAL ARTERY, AND THEIR BRANCHES, LEFT SIDE.


Superior external articular artery
Superior internal articular artery
Inferior external articular artery
Inferior internal articular artery
Anterior tibial recurrent artery
Extensor longus digitorum
Anterior tibial artery
Tibialis anticus muscle
Extensor longus digitorum, turned back
ANTERIOR TIBIAL NERVE
Peroneus tertius
Extensor longus hallucis
Anterior peroneal artery
Internal malleolar artery
External malleolar artery
Anterior annular ligament
Dorsalis pedis artery
Peroneus brevis muscle
Innermost tendon of extensor brevis digitorum
Extensor brevis digitorum, cut
Communicating branch
External tarsal branch
Dorsalis hallucis artery
Metatarsal branch
Dorsal interosseous artery

To its **inner side** along its upper two-thirds is the tibialis anticus muscle; but at the lower third it is crossed by the tendon of the extensor proprius hallucis, and then for the rest of its course has this tendon overlapping it or to its inner side.

On its **outer side** it is in contact in its upper third with the extensor longus digitorum muscle; in its middle third with the extensor proprius hallucis; but, as this muscle crosses to the inner side of the artery, the vessel usually for a very short part of its course comes again into contact with the extensor longus digitorum. At the upper and lower thirds of its course on the front of the leg the artery has the anterior tibial nerve to its outer side.

In front the artery is covered by the skin, superficial and deep fascia. In its upper two-thirds it is deeply placed in the cellular interval between the tibialis anticus on the inner side, and the extensor longus digitorum and extensor proprius hallucis on its outer side; and in its lower third it is crossed from without inwards by the tendon of the extensor proprius hallucis, and lies beneath the anterior annular ligament of the ankle-joint. The anterior tibial nerve is usually in front of the artery in the middle third of the leg.

The **branches of the anterior tibial artery** are:—(1) The posterior tibial recurrent; (2) the superior fibular; (3) the anterior tibial recurrent; (4) the muscular; (5) the internal malleolar; and (6) the external malleolar.

(1) The **posterior tibial recurrent** is occasionally absent. It ascends between the popliteus muscle and the posterior ligament of the knee-joint supplying these structures and the superior tibio-fibular joint. It anastomoses with the inferior external articular branch of the popliteal, and to a less extent with the inferior internal articular branch.

(2) The **superior fibular** is a branch of small size which arises from the main trunk just before it passes through the interosseous space. It winds round the neck of the fibula, pierces the attachment of the soleus and is distributed to that muscle and to the skin.

(3) The **anterior tibial recurrent** is given off from the anterior tibial artery immediately after that vessel has passed through the interosseous membrane. It winds tortuously through the substance of the tibialis anticus muscle, over the outer tuberosity of the tibia close to the bone; and, perforating the deep fascia, ramifies on the lower and outer part of the capsule of the knee-joint. It anastomoses with the inferior and superior external articular branches of the popliteal, with the descending branch of the external circumflex, and somewhat less freely with the internal articular branches of the popliteal and with the anastomotica magna. It gives off small branches to the tibialis anticus, the extensor longus digitorum, the knee-joint, and the contiguous fascia and skin. It forms one of the collateral channels by which the blood is carried to the limb below in obstruction of the popliteal artery (fig. 376).

(4) The **muscular branches**, some ten or twelve in number, arise irregularly from either side of the artery as it courses down the limb, and supply the contiguous muscles.

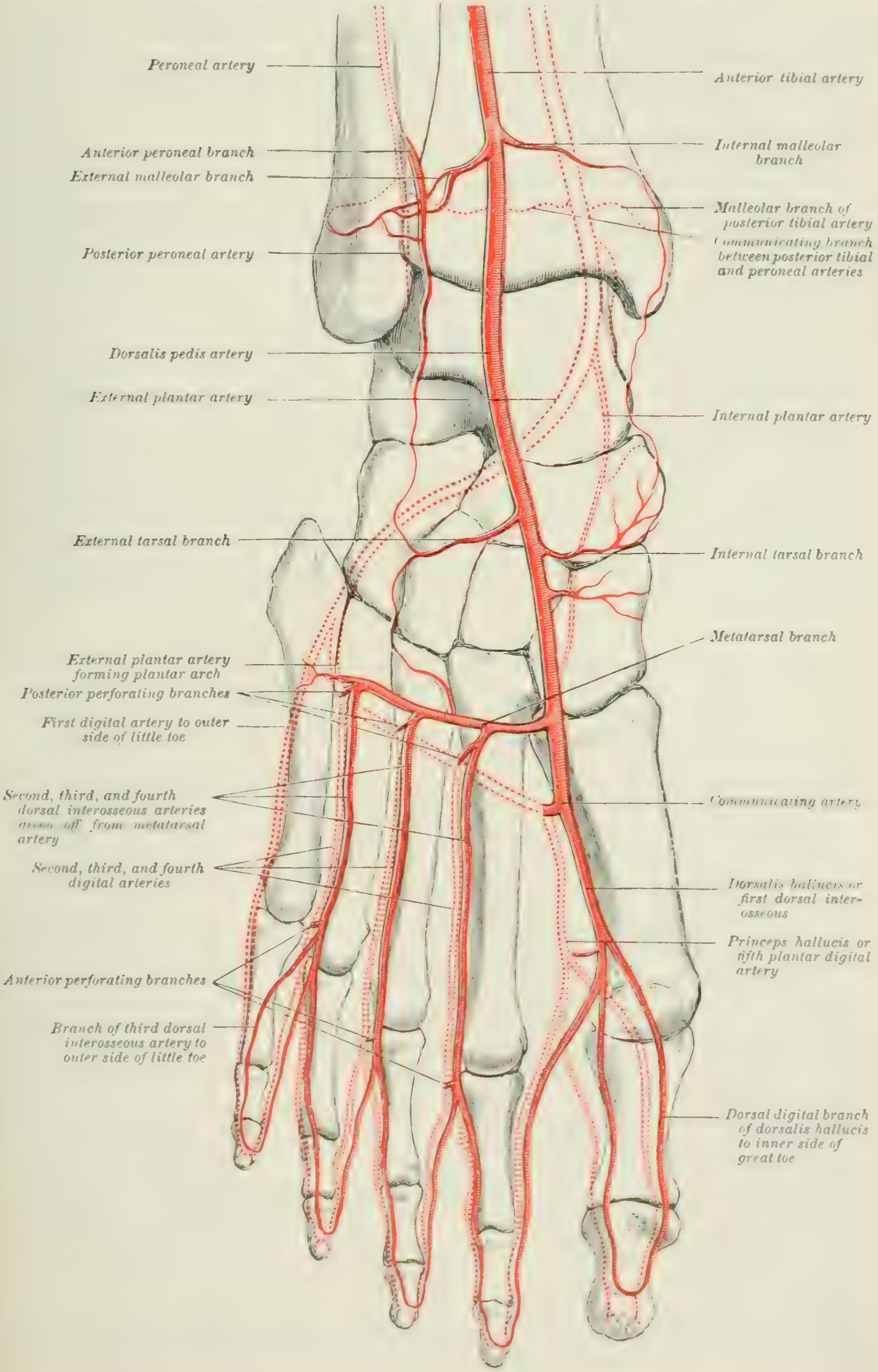
(5) The **internal malleolar,** the smaller of the two malleolar branches, arises from the lower part of the anterior tibial artery a little higher than the external, usually about the spot where the tendon of the extensor longus hallucis crosses the anterior tibial artery. It winds inwards over the internal malleolus, passing beneath the tibialis anticus, and forms an internal malleolar plexus or rete about the inner ankle over the lower end of the tibia by anastomosing with branches from the posterior tibial, internal plantar, and internal calcanean arteries.

(6) The **external malleolar,** larger than the internal, arises from the outer side of the anterior tibial artery, usually on a lower level than the internal malleolar. It winds in an outward and downward direction round the external malleolus, passing beneath the extensor longus digitorum and peroneus tertius, and forms the external malleolar plexus or rete by anastomosing with the anterior peroneal, the termination of the peroneal, the external plantar, and the external tarsal branch of the dorsalis pedis (fig. 381).

The anastomosis between the external malleolar and anterior peroneal is sometimes of considerable size, supplying the blood to the dorsal artery of the foot; the anterior tibial, then much reduced in size, usually ends at the spot where the external malleolar is usually given off.

FIG. 381.—SCHEME OF THE DISTRIBUTION AND ANASTOMOSES OF THE ARTERIES OF THE RIGHT FOOT. (Walsham.)

(The plantar arteries are shown in dotted outline; the dorsal in solid red.)


Peroneal artery
Anterior tibial artery
Anterior peroneal branch
Internal malleolar branch
External malleolar branch
Malleolar branch of posterior tibial artery
Communicating branch between posterior tibial and peroneal arteries
Posterior peroneal artery
Dorsalis pedis artery
External plantar artery
Internal plantar artery
External tarsal branch
Internal tarsal branch
Metatarsal branch
External plantar artery forming plantar arch
Posterior perforating branches
First digital artery to outer side of little toe
Second, third, and fourth dorsal interosseous arteries given off from metatarsal artery
Communicating artery
Second, third, and fourth digital arteries
Dorsalis hallucis or first dorsal interosseous
Princeps hallucis or fifth plantar digital artery
Anterior perforating branches
Branch of third dorsal interosseous artery to outer side of little toe
Dorsal digital branch of dorsalis hallucis to inner side of great toe

THE DORSALIS PEDIS ARTERY

The **dorsalis pedis artery** is a continuation of the anterior tibial. It extends from the front of the ankle-joint to the proximal end of the first interosseous space where it dips into the sole to join the external plantar artery and complete the plantar arch. The course of the artery is indicated by a line drawn from a point midway between the two malleoli to the proximal end of the first metatarsal space.

Relations.—Behind, the artery from above downwards lies successively on the astragalus, scaphoid, middle cuneiform, and the base of the second metatarsal bones, and the ligaments uniting these bones. As it sinks into the sole, under the name of the communicating artery, it lies between the two heads of origin of the first dorsal interosseous muscle. At times it takes a course a little more outwards, then lying either partly on the middle cuneiform bone, or on the dorsal ligaments uniting the middle cuneiform to the internal cuneiform. It is more or less bound down to the bones by aponeurotic fibres derived from the deep fascia.

In front, the artery is covered by the anterior annular ligament, sometimes by the extensor longus hallucis, by the skin, the superficial and deep fascia, and, just before it sinks into the sole, by the innermost tendon of the extensor brevis digitorum. The angle formed by this tendon with the extensor longus hallucis is the best guide to finding the artery in the process of ligature (fig. 380).

To its **outer side** is the innermost tendon of the extensor longus digitorum, and lower down the innermost tendon of the extensor brevis digitorum. The anterior tibial nerve is also to its outer side, as is also the outermost of its venæ comites.

To its **inner side** is the extensor longus hallucis, except at times for about half an inch below, where the innermost tendon of the extensor brevis digitorum, having crossed the artery, may lie between it and this tendon. The innermost of the venæ comites is also to the inner side. Branches between the venæ comites at intervals cross the vessel.

The **branches of the dorsalis pedis artery** are:—(1) The tarsal; (2) the metatarsal; (3) the dorsalis hallucis; and (4) the communicating, or plantar digital.

(1) The **tarsal branches** may be divided into (*a*) the external, and (*b*) the internal. (*a*) The **external tarsal** runs outwards over the scaphoid and cuboid bones, beneath the extensor brevis digitorum. It supplies branches to that muscle, and to the bones and the articulations between them, and anastomoses above with the external malleolar and anterior peroneal, below with the metatarsal, and externally over the outer border of the foot with the anastomotic branches of the external plantar artery. (*b*) The **internal tarsal** consists of a few small branches which run over the inner side of the foot, supplying the skin and articulations, and anastomose with the internal malleolar.

(2) The **metatarsal artery** (figs. 380, 381) runs outwards across the foot, in a slight curve with the convexity forwards, over the bases of the metatarsal bones, and beneath the extensor tendons and the extensor brevis digitorum. At the outer border of the foot it anastomoses, above with the external tarsal, and externally with the anastomotic branches of the external plantar. From the convexity of the arch it gives off three **dorsal interosseous arteries,** which run forwards on the dorsal interosseous muscles in the centre of the second, third, and fourth interosseous spaces to the cleft of the toes, where they bifurcate for the supply of the contiguous sides of the second and third toes, the third and fourth toes, and the fourth and fifth toes. The outermost of the interosseous branches gives off a small vessel for the supply of the outer side of the little toe. At the proximal end of the second, third, and fourth interosseous spaces each artery receives a branch of communication from the external plantar artery (posterior perforating), and immediately before they bifurcate a second communicating artery through the distal end of the interosseous space from the corresponding digital vessel (anterior perforating artery).

The little **dorsal digital vessels,** into which the dorsal interosseous arteries divide at the cleft of the toes, run along the side of each toe towards the dorsal aspect, anastomosing with each other across the dorsum of the toes and by frequent branches with the collateral digital branches of the digital arteries, which also run along the sides of the toes, but nearer the plantar surface. At the end of the toes they anastomose with each other around the quick of the nail.

(3) The **dorsalis hallucis**—or first dorsal interosseous artery, as it is sometimes called—is the apparent continuation of the dorsalis pedis. Like the other dorsal interosseous arteries, it passes forwards, in the centre of the first interosseous space, on the first dorsal interosseous muscle. At the cleft of the toes it divides into two **dorsal digital branches**—the one for the supply of the outer side of the great toe, the other for the inner side of the second toe. Before its bifurcation the dorsalis hallucis gives off a small branch, which runs inwards, under the extensor longus hallucis, for the supply of the inner side of the great toe; but this branch is sometimes absent. At the front of the space, immediately before its bifurcation, the dorsalis hallucis communicates with the fifth plantar digital artery, or princeps hallucis, through an anterior perforating artery (fig. 381).

(4) The **communicating**—first interosseous perforating, or plantar digital artery, as it is variously called—comes off from the dorsalis pedis with the dorsalis hallucis (into which arteries indeed the dorsalis pedis may be said to divide). At the back of the first interosseous space it dips into the sole between the two heads of the first dorsal interosseous muscle, and communicates with the termination of the external plantar artery, completing the plantar arch, in a manner similar to that in which the radial artery, passing through the first dorsal interosseous muscle in the hand, completes by inosculating with the ulnar the deep palmar arch. At the spot where it joins the external plantar it gives off the **fifth plantar digital artery**, or **princeps hallucis**, which runs forwards in the centre of the first interosseous space to the cleft between the first and second toe, where it divides into collateral branches for the adjacent side of each. Before bifurcating, it supplies a branch to the inner side of the great toe, and receives the anterior communicating artery from the dorsalis hallucis.

THE VEINS

THE **veins,** like the arteries, are divided into the pulmonary and the systemic. The **pulmonary** return the aërated blood from the lungs to the left side of the heart, and are the only veins that contain arterial blood. The **systemic veins** bring back to the right side of the heart the impure venous blood from the rest of the body. All the systemic veins terminate ultimately either in the superior or inferior vena cava, except the cardiac veins, which return the blood from the heart's substance, and open directly into the right auricle.

The veins from the stomach and intestines, the spleen, and the pancreas, before opening into the inferior vena cava, are collected into a large trunk vein called the **portal vein,** which breaks up, like an artery, into capillaries in the substance of the liver. From these capillaries the blood is again collected by the hepatic veins, which finally open, as two or more large-sized vessels, into the inferior vena cava.

The veins are described under the heads of:—1. The veins of the thorax; 2. the veins of the head and neck; 3. the veins of the spine; 4. the veins of the abdomen; 5. the veins of the upper extremity; and 6. the veins of the lower extremity.

1. *THE VEINS OF THE THORAX*

The **veins of the thorax** are: the pulmonary, which carry the blood from the lung to the left side of the heart; and the superior vena cava and its tributaries, which return the venous blood from the head and neck, the upper extremities, and the walls of the thorax, to the right side of the heart. The inferior vena cava, which brings back the blood from the abdomen and pelvis and lower extremities, is described with the veins of the abdomen, in which cavity it lies throughout by far the greater part of its course, somewhat less than half an inch of its upper end only being situated in the thorax.

The pulmonary veins are contained in the middle mediastinum. The superior vena cava and the right and left innominate veins course through the superior mediastinum. The azygos veins, the larger of which opens into the superior vena cava, lie on either side of the thoracic vertebra in the posterior mediastinum. They receive the intercostal, the bronchial, and the œsophageal veins.

THE PULMONARY VEINS

The **pulmonary veins** (fig. 320) return the aërated blood from the lungs to the heart. They are usually four in number, two right and two left. Occasionally, however, there are three pulmonary veins on the right side, the result of the vein from the middle lobe of the right lung opening separately into the left auricle instead of joining as usual the upper of the two right pulmonary veins. The relations of the pulmonary veins to the pulmonary arteries and bronchi in the lungs are given with the ANATOMY OF THE LUNGS. At the root of the lung the pulmonary veins on both sides are arranged as an upper and a lower branch, an anterior descending branch of the bronchus passing between them. The upper vein on the right side is larger than the lower, and usually receives the vein from the middle lobe of the right lung. The lower vein on the left side is larger than the upper. Both the upper and lower veins lie in front of the pulmonary artery and on a lower plane, and run almost horizontally inwards and forwards to the left auricle. As they pierce the pericardium they receive a reflexion from the serous layer of that membrane. Their relations within the pericardium are given with the ANATOMY OF THE HEART. At the root of the lung their relations to the surrounding structures are similar to those of the pulmonary artery (page 466). A separate description is not required.

THE VENA CAVA SUPERIOR

The **superior** or **descending vena cava** (fig. 381A) carries to the heart the blood returned from the head and neck and upper extremities through the right and left innominate veins, and from the walls of the thorax, either directly through the greater azygos vein, or indirectly through the innominate veins. It is formed (fig. 381A) by the confluence of the right and left innominate veins at the lower border of the first right costal cartilage close to the sternum, and, descending from this spot in a gentle curve with its convexity to the right and in a direction slightly backwards and outwards behind the sternal end of the first and second intercostal spaces and second costal cartilage, terminates in the right auricle of the heart on a level with the third right costal cartilage in front and the seventh thoracic vertebra behind. It measures about three inches in length (7–8 cm.). A little more than its lower half (4 cm.) is contained within the pericardium, the serous layer of that membrane being reflected obliquely over it immediately below the spot where it is joined by the vena azygos major, and on a lower level than the reflexion of the pericardium on the aorta. The vena cava superior contains no valve.

Relations.—In front (fig. 322), in addition to the first and second intercostal spaces and the second costal cartilage, it is covered by the remains of the thymus gland, the interthoracic fascia, and the pericardium, and is overlapped by the right pleura and lung.

Behind (fig. 324) are the vena azygos major, the right bronchus, the right pulmonary artery, and the superior right pulmonary vein; and below, the fibrous layer of the pericardium. The serous layer is reflected over the front and sides of the vessel, but not over its posterior part.

To the **right side** are the right lung and pleura, and the phrenic nerve.

To the **left side** are the innominate artery and the first or ascending portion of the arch of the aorta.

Tributaries.—In addition to the right and left innominate veins and the vena azygos major, it receives small veins from the mediastinum and pericardium.

THE INNOMINATE OR BRACHIO-CEPHALIC VEINS

The **innominate veins** return the blood from the head and neck and upper extremity. They are formed on each side by the confluence of the internal jugular and subclavian veins behind the sternal end of the clavicle. They terminate at the lower border of the first costal cartilage on the right side by uniting to form the superior vena cava. The innominate veins have no valves.

The **right innominate vein** (fig. 382) measures about one to one and a half inches in length (2–3 cm.), and descends from its origin behind the sternal end of the clavicle, very slightly forwards and inwards, superficial to, and to the right of, the subclavian and innominate arteries, to its junction with the left vein behind the first costal cartilage close to the sternum.

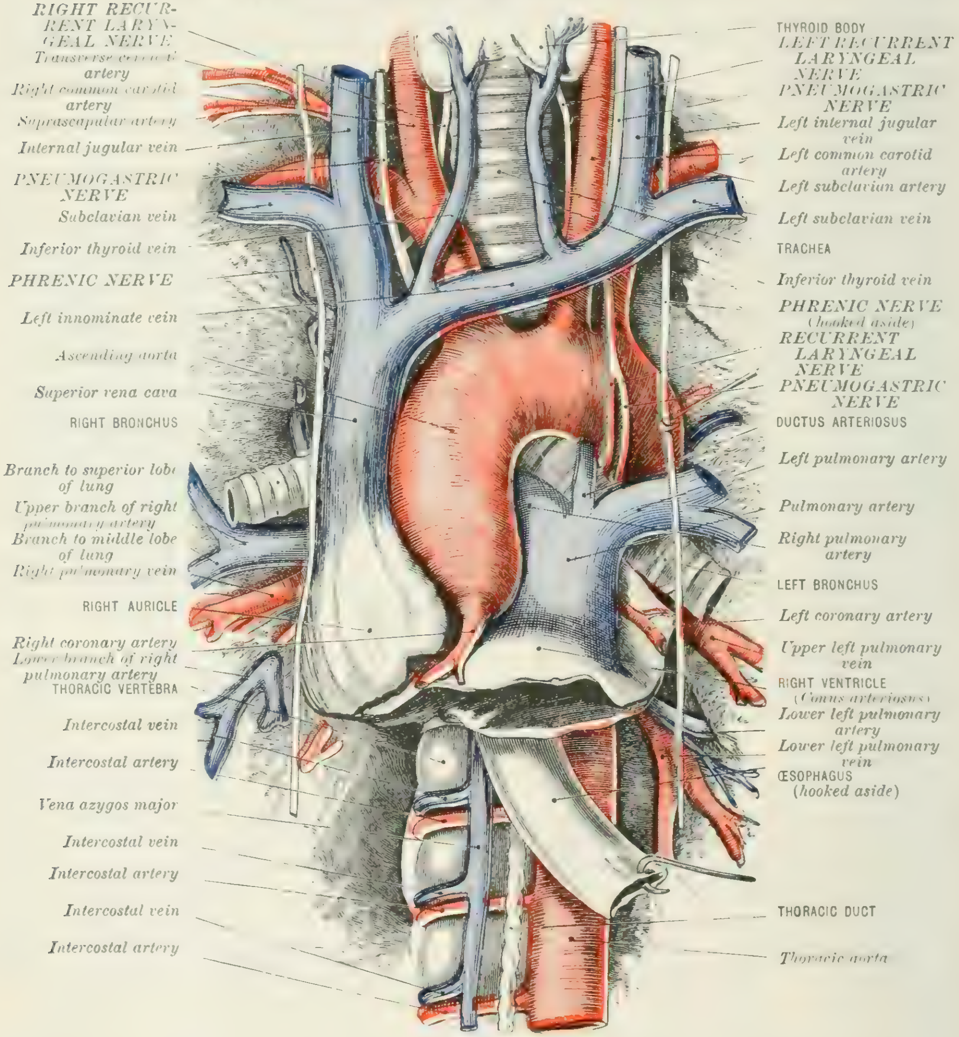
Relations.—In front (fig. 327) are the origins of the sterno-hyoid and sterno-thyroid muscles, the clavicle, the first costal cartilage, and the remains of the thymus gland.

Behind are the pleura and lung.

To the **right** are the right pleura and lung, and the phrenic nerve.

FIG. 381A.—THE VENA CAVA SUPERIOR AND THE INNOMINATE VEINS.

(From a dissection in St. Bartholomew's Hospital Museum.)


RIGHT RECURRENT LARYNGEAL NERVE
Transverse cervical artery
Right common carotid artery
Suprascapular artery
Internal jugular vein
PNEUMOGASTRIC NERVE
Subclavian vein
Inferior thyroid vein
PHRENIC NERVE
Left innominate vein
Ascending aorta
Superior vena cava
RIGHT BRONCHUS
Branch to superior lobe of lung
Upper branch of right pulmonary artery
Branch to middle lobe of lung
Right pulmonary vein
RIGHT AURICLE
Right coronary artery
Lower branch of right pulmonary artery
THORACIC VERTEBRA
Intercostal vein
Intercostal artery
Vena azygos major
Intercostal vein
Intercostal artery
Intercostal vein
Intercostal artery
THYROID BODY
LEFT RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
Left internal jugular vein
Left common carotid artery
Left subclavian artery
Left subclavian vein
TRACHEA
Inferior thyroid vein
PHRENIC NERVE (hooked aside)
RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
DUCTUS ARTERIOSUS
Left pulmonary artery
Pulmonary artery
Right pulmonary artery
LEFT BRONCHUS
Left coronary artery
Upper left pulmonary vein
RIGHT VENTRICLE (Conus arteriosus)
Lower left pulmonary artery
Lower left pulmonary vein
ŒSOPHAGUS (hooked aside)
THORACIC DUCT
Thoracic aorta

To the **left** (fig. 381A) are the right subclavian artery, the innominate artery, the right pneumogastric nerve, and the trachea.

The **left innominate vein** (fig. 381A) measures two and a half to three inches in length (6–7 cm.), and extends from its origin behind the sternal end of the left clavicle obliquely across the three main branches of the arch of the aorta to unite with the right innominate vein at the lower border of the cartilage of the first rib close to the sternum to form the vena cava superior. In this course it runs from left to right with an inclination downwards and slightly backwards. A line drawn obliquely across the upper half of the manubrium of the sternum, from the sterno-clavicular articulation on the left side to the lower border of the first costal cartilage at its junction with the sternum on the right side, will indicate its course. The left innominate vein is on a level with the top of the sternum at birth.

Relations.—In front, in addition to the manubrium of the sternum, it has the origins of the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland, the sternal end of the left clavicle, and the sterno-clavicular articulation (figs. 328, 381A).

Behind, are the three chief arteries arising from the arch of the aorta, the trachea, and the left phrenic and left pneumogastric nerves.

Below it is the transverse portion of the arch of the aorta.

Above it are the cervical fascia and inferior thyroid veins.

Tributaries.—In addition to the internal jugular and subclavian veins, by the confluence of which the innominate veins are formed, each vein receives on its upper aspect the vertebral, the deep cervical and inferior thyroid veins; and on its lower aspect the internal mammary vein. The left vein, moreover, is joined by the left superior intercostal, and by the thymic, mediastinal, and pericardiac veins. At the confluence of the internal jugular and subclavian veins on the right side, the right lymphatic duct opens; on the left side the thoracic duct. The vertebral, the deep cervical, and the inferior thyroid veins are described with the deep veins of the head and neck (page 628).

The **internal mammary veins** (fig. 344) are formed by the union of the venæ comites of the superior epigastric and musculo-phrenic branches of the internal mammary artery. They receive in their course through the chest collateral tributaries corresponding to the branches of the internal mammary artery. Just before reaching the innominate vein they unite behind the first intercostal space to form a single trunk which opens into the innominate vein on the inner side of the internal mammary artery. They contain many valves.

The **left superior intercostal vein**—or, more correctly speaking, the lower left superior intercostal vein—longer than the right, which is described as a tributary of the vena azygos major, receives the intercostal veins from the three or four upper left intercostal spaces except from the first space, and, ascending over the arch of the aorta, opens into the left innominate vein. It usually receives the left bronchial vein, and communicates with the upper left azygos vein. (See INTERCOSTAL VEINS, page 608.)

The **mediastinal, pericardiac,** and **thymic veins** are small vessels, corresponding to the arteries of those names given off by the internal mammary. They do not, however, as a rule, join the internal mammary vein, but unite into a single trunk (figs. 317, 382), which passes over the transverse part of the arch of the aorta, and opens into the lower and anterior part of the left innominate vein.

Chief Variations in the Superior Vena Cava and Innominate Veins

The variations in the vena cava and innominate veins depend upon certain abnormalities in the development of the great veins from the ducts of Cuvier and the primitive jugular veins, and can here receive only a brief mention. They may be classified as follows :—

(1) *Variations due to the Persistence of the Left Duct of Cuvier*

(*a*) The left subclavian may join the left internal jugular vein to form a trunk which is continued almost vertically downwards over the arch of the aorta in front of the root of the left lung, to open into the coronary sinus of the heart. This variety is known as the persistent left superior vena cava, and is the normal arrangement of the great anterior veins in some animals. The rudiments of this vein are found in Man in the so-called oblique vein of Marshall, which stretches from the coronary sinus through the vestigial fold of the pericardium, and is often continued as a fine fibrous cord to the superior intercostal vein.

When the so-called left superior vena cava is present, the upper left azygos vein (the remains of the left primitive cardinal vein) may open into it by arching over the root of the left lung in a way similar to that in which the greater azygos (the right primitive cardinal vein) opens into the superior vena cava over the root of the right lung. The normal left innominate vein may be absent, or may be quite small or rudimentary, the result of the non-development, or only partial development, of a transverse branch (which becomes the left innominate) when the left part of the sinus venosus and the left duct of Cuvier are transformed into the coronary sinus, the oblique vein of Marshall, and the upper portion of the left superior intercostal vein.

(*b*) A vein may run from the left innominate, or left superior intercostal vein, through the vestigial fold of the pericardium to the coronary sinus, the left innominate vein being itself normal. This abnormality is similar in kind, but minor in degree, to the former, described under (*a*).

(2) *Variations due to Persistence of the Left and Suppression of the Right Duct of Cuvier*

(*a*) The right innominate vein may cross the arch of the aorta to join a vertical left innominate vein, and thus form a left superior vena cava, the normal right superior cava being absent. The arrangement of the azygos veins under this condition may be reversed, there being a left vena azygos major opening over the root of the left lung into the left superior cava, and an upper and lower right azygos vein arranged after the manner of the normal left azygos veins. This arrangement of the veins may occur independently of any general transposition of the viscera.

(*b*) There are many other varieties, depending upon abnormalities in the normal development of the great veins from the Cuvierian ducts and from the primitive jugular and cardinal veins; but these cannot be discussed here.

THE AZYGOS VEINS

The **azygos veins** (fig. 382) are three in number. They collect the blood returned from the eleven intercostal spaces on the right side, and from the seven or eight lower intercostal spaces on the left side. They lie on each side of the front of the bodies of the thoracic vertebræ, and establish a communication between the superior and inferior venæ cavæ through the ascending lumbar veins.

The **vena azygos major** begins in the abdomen, where it may be looked upon as a continuation upwards of the ascending lumbar vein (page 633). It passes through the aortic opening of the diaphragm, runs up through the posterior mediastinum on the right side of the front of the bodies of the thoracic vertebræ as high as the fourth thoracic vertebra; then curves forwards over the root of the right lung, and opens into the superior vena cava immediately before the latter pierces the pericardium.

Relations.—(1) In the **abdomen,** the vena azygos major lies to the right of the aorta and thoracic duct, under cover of the right crus of the diaphragm, upon the first, sometimes upon the second, lumbar vertebra. At this spot it receives the right subcostal vein, and is continued below into the ascending lumbar vein; or, if the lower part of this vein is small, it may appear to begin in one of the lumbar veins, or in the vena cava, or where the portion of the ascending lumbar vein which communicates with the renal is enlarged, in the renal vein. Through this intermediation of the ascending lumbar vein, a communication is established between the iliac veins and the vena azygos. In obstruction of the inferior vena cava much of the blood from the lower extremities and abdominal wall is returned by the vena azygos major and its continuation, the ascending lumbar vein, in the abdomen, to the vena cava superior. (See ASCENDING LUMBAR VEIN, page 633.)

(2) At the **aortic opening** the vena azygos major lies to the right of the aorta and thoracic duct, between the crura of the diaphragm.

(3) In the **posterior mediastinum,** as it courses upwards on the right side of the bodies of the thoracic vertebræ, the vena azygos major crosses **in front** of the lower right intercostal arteries, having on its **left side** the descending aorta and thoracic duct, **in front** the root of the right lung and lower down the pleura, and on its **right side** the right pleura and lung.

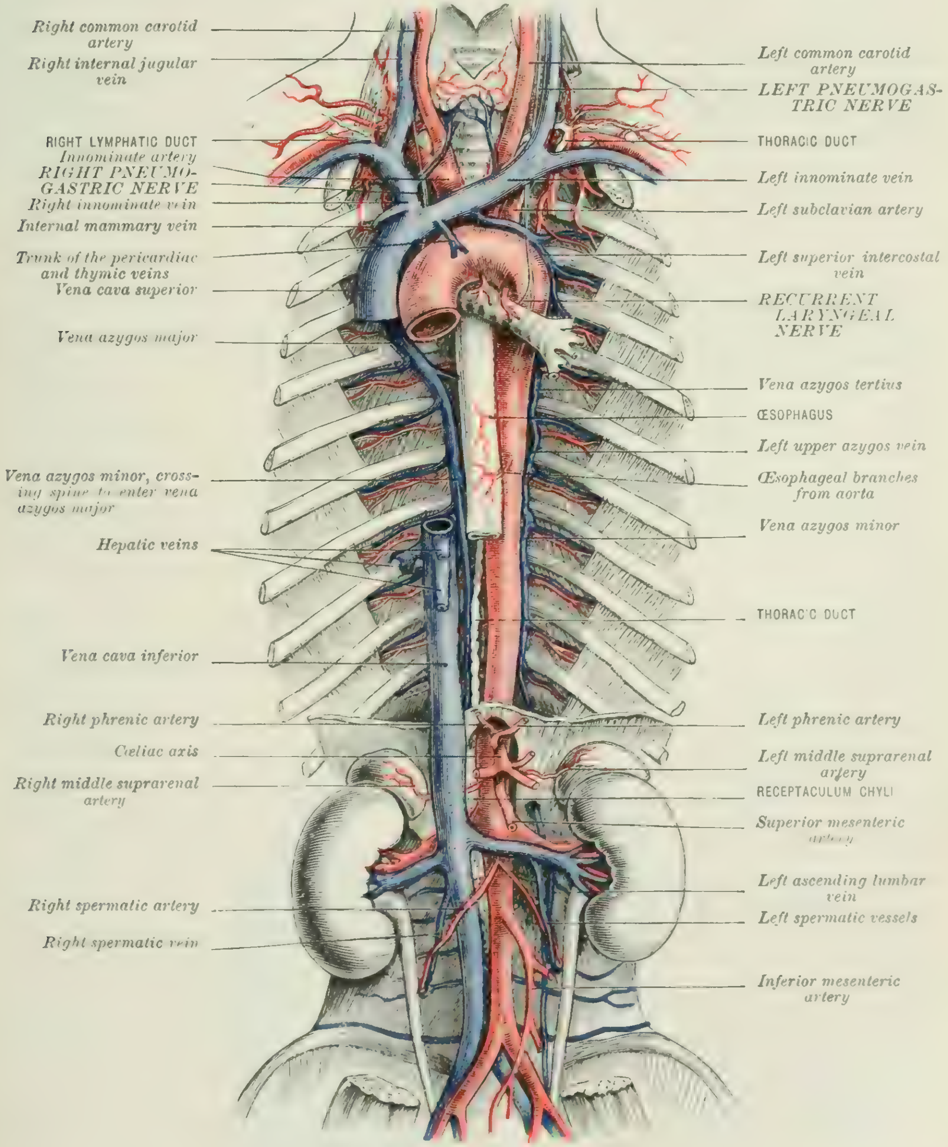
(4) As it **curls over the root** of the right lung, the vena azygos major is in contact with the right bronchus, the pneumogastric nerve passing obliquely between them (fig. 324).

It usually contains an imperfect pair of valves at the spot where it turns forwards from the fourth thoracic vertebra to arch over the root of the lung; and still more imperfect valves are found at varying intervals lower down the vein.

Tributaries.—(1) The vena azygos minor; (2) the vena hemiazygos accessoria, or one or more of the left intercostal veins; (3) the lower end of the lower superior intercostal vein of the left side (sometimes); (4) the lower right œsophageal veins; (5) a few right mediastinal veins; (6) the right bronchial vein; (7) the lower right superior intercostal vein; (8) the nine lower right intercostal veins; and (9) the right subcostal vein.

The **vena azygos minor**—also called the **lower left azygos** and **vena hemiazygos**—begins in the abdomen by communicating, like the vena azygos major, with the ascending lumbar vein of the left side. Through this vein it communicates with the lumbar veins, the renal, and the iliac veins, and, according as one or other portion of the ascending lumbar is enlarged and other portions are diminished in size or obliterated, so may the vena azygos minor appear to begin in the vena cava inferior or in a lumbar, the renal, or one of the iliac veins. The vena azygos minor, after receiving the left subcostal vein, passes through the left crus of the diaphragm, and courses up the posterior mediastinum to the left of the bodies of

FIG. 382.—THE SUPERIOR AND INFERIOR VENÆ CAVÆ, THE INNOMINATE VEINS, AND THE AZYGOS VEINS.


Right common carotid artery
Right internal jugular vein
RIGHT LYMPHATIC DUCT
Innominate artery
RIGHT PNEUMOGASTRIC NERVE
Right innominate vein
Internal mammary vein
Trunk of the pericardiac and thymic veins
Vena cava superior
Vena azygos major
Vena azygos minor, crossing spine to enter vena azygos major
Hepatic veins
Vena cava inferior
Right phrenic artery
Cœliac axis
Right middle suprarenal artery
Right spermatic artery
Right spermatic vein
Left common carotid artery
LEFT PNEUMOGASTRIC NERVE
THORACIC DUCT
Left innominate vein
Left subclavian artery
Left superior intercostal vein
RECURRENT LARYNGEAL NERVE
Vena azygos tertius
ŒSOPHAGUS
Left upper azygos vein
Œsophageal branches from aorta
Vena azygos minor
THORACIC DUCT
Left phrenic artery
Left middle suprarenal artery
RECEPTACULUM CHYLI
Superior mesenteric artery
Left ascending lumbar vein
Left spermatic vessels
Inferior mesenteric artery

the lower thoracic vertebræ as high as the eighth, where it turns obliquely to the right, and, crossing in front of the spinal column behind the aorta and the œsophagus, opens into the vena azygos major. In its course it crosses over three or four of the lower left intercostal arteries, and is covered by the pleura.

Tributaries.—(1) The lower four left intercostal veins; (2) the left subcostal vein; (3) the lower end of the third azygos vein (sometimes); (4) small left mediastinal veins; and (5) the lower left œsophageal veins.

The **vena azygos tertia** (also called the **upper left azygos** and **vena hemiazygos accessoria**) varies considerably in size, position, and arrangement, and is often absent. It lies in the posterior mediastinum by the left side of the bodies of the fifth, sixth, and seventh thoracic vertebræ, and is more or less vertical in direction. It is continued above into the lower left superior intercostal vein, and below either joins the vena azygos minor, or passes obliquely across the sixth or seventh thoracic vertebra to join the vena azygos major. The intercostal veins intervening between it and the vena azygos minor then open directly across the spine into the vena azygos major. It crosses the corresponding left intercostal arteries, and is covered by the pleura.

Tributaries.—(1) The fifth, sixth, and sometimes the seventh intercostal veins; (2) the lower end of the lower left superior intercostal vein; (3) the upper end of the vena azygos minor (sometimes); and (4) the left bronchial vein.

The intercostal veins.—The intercostal veins are eleven in number on each side, and correspond with the intercostal arteries. The last thoracic vein is here called the **subcostal,** and is described separately (page 609). There is one vein to each intercostal artery, the vein lying above the artery whilst in the intercostal space. Each vein is joined by a dorsal tributary which runs with the dorsal branch of the intercostal artery between the transverse process of the vertebræ and the neck of the rib. The dorsal tributaries return the blood from the muscles of the back, and receive communicating branches from the dorsal spinal plexus and from the spinal veins through the intervertebral foramina. The intercostal veins also receive small tributaries from the bodies of the vertebræ. The termination of the intercostal veins is different on the two sides, and is seldom alike in any two consecutive subjects.

On the right side.—The first intercostal vein (the **upper right superior intercostal vein**) ascends with the superior intercostal artery, a branch of the subclavian, to end either in the vertebral vein just before the latter joins the right innominate vein, or in the right innominate direct. The second intercostal vein either joins with the first, and opens with it as a common trunk into the vertebral or innominate vein, or it joins with the third or with the third and fourth to open into the vena azygos major as the latter is arching over the root of the right lung. This vein is known as the **lower right superior intercostal vein.** The fifth, sixth, seventh, eighth, ninth, tenth, and eleventh right intercostal veins join the vena azygos major. The upper of these have well-marked valves where they join the azygos vein. In the lower veins these valves are imperfect. All the intercostal veins are provided with valves in their course between the muscles.

On the **left side** the first intercostal vein also follows the superior intercostal artery from the subclavian, and ascends to join the left vertebral or left innominate vein, and is known as the **upper left superior intercostal vein.** The second intercostal vein either joins the first, and opens with it as a common trunk into the left vertebral or left innominate vein, or joins the third and fourth, as described below, to form the **lower left superior intercostal vein.** The third and fourth, and sometimes the second, intercostal veins unite to form a single trunk, the **lower left superior intercostal vein,** which passes upwards across the arch of the aorta, and opens into the left innominate vein. This vein usually communicates at its lower end with the third azygos vein, but at times crosses the spine, and enters directly the vena azygos major. A fibrous cord can frequently be traced from it through the vestigial fold of the pericardium to the oblique vein of Marshall (page 605). The fifth and sixth, and sometimes the seventh, intercostal veins either end in the third azygos vein, or, if this is absent, cross the spine, and open directly into the vena azygos major. The eighth, ninth, tenth, and eleventh, and sometimes the seventh, intercostal veins join the vena azygos minor.

The **subcostal vein,** or **twelfth thoracic vein,** lies beneath the last rib, and accompanies the twelfth dorsal or subcostal artery. It receives tributaries corresponding to the branches of the subcostal artery, and opens on the right side into the vena azygos major, and on the left side into the vena azygos minor.

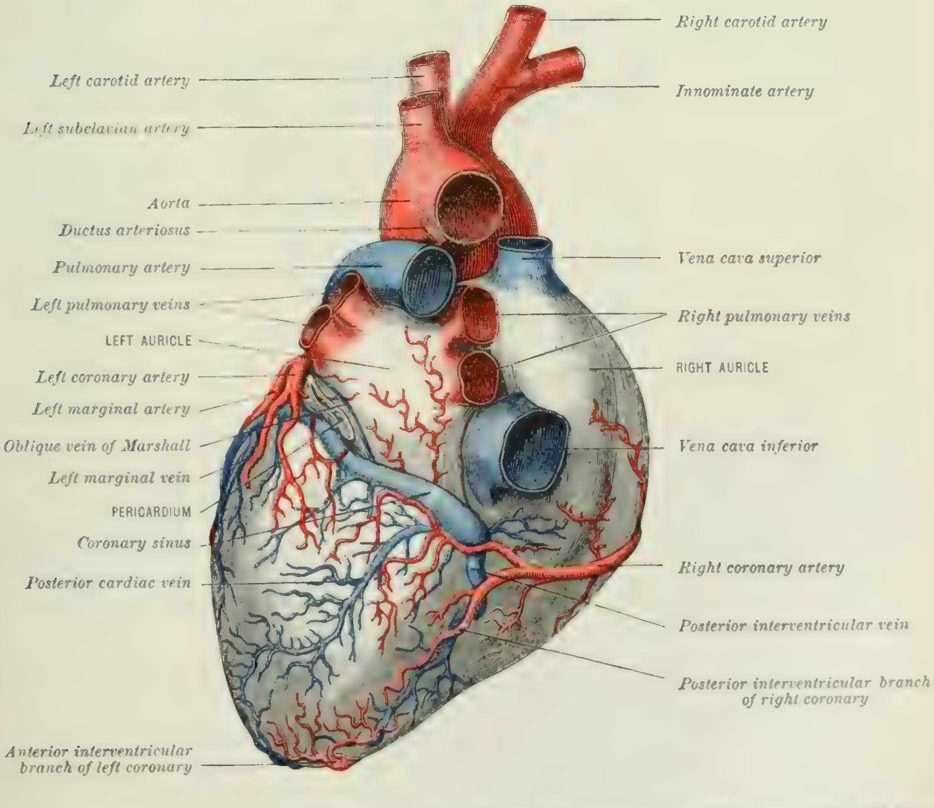
The **bronchial veins** correspond to the bronchial arteries, but do not return the whole of the blood carried to the lungs by those vessels—that part which is distributed to the smaller bronchial tubes and the alveolæ being brought back by the pulmonary veins. The bronchial veins issue from the lung substance behind the structures forming the root of the lung. The right vein generally joins the vena azygos major just before the latter vein enters the superior vena cava. The left vein opens into the lower left superior intercostal vein, or into the upper left azygos vein. The bronchial veins at the root of the lung receive small tributaries from the bronchial glands, from the trachea, and from the posterior mediastinum.

The **œsophageal veins** from the thoracic portion of the œsophagus end in part in the vena azygos major, and in part in the vena azygos minor.

THE VEINS OF THE HEART

The **cardiac** or **coronary veins** return the blood from the substance of the heart. They accompany the corresponding coronary arteries, and terminate for the most part in a dilated vein known as the coronary sinus. This opens directly into the right auricle of the heart, between the tricuspid opening and the opening of the inferior vena cava. Some smaller veins from the heart's substance (venæ minimæ cordis) open separately and directly into the right auricle at the bottom of some of the small depressions known as the foramina Thebesii.

Fig. 383.—The Coronary Sinus.

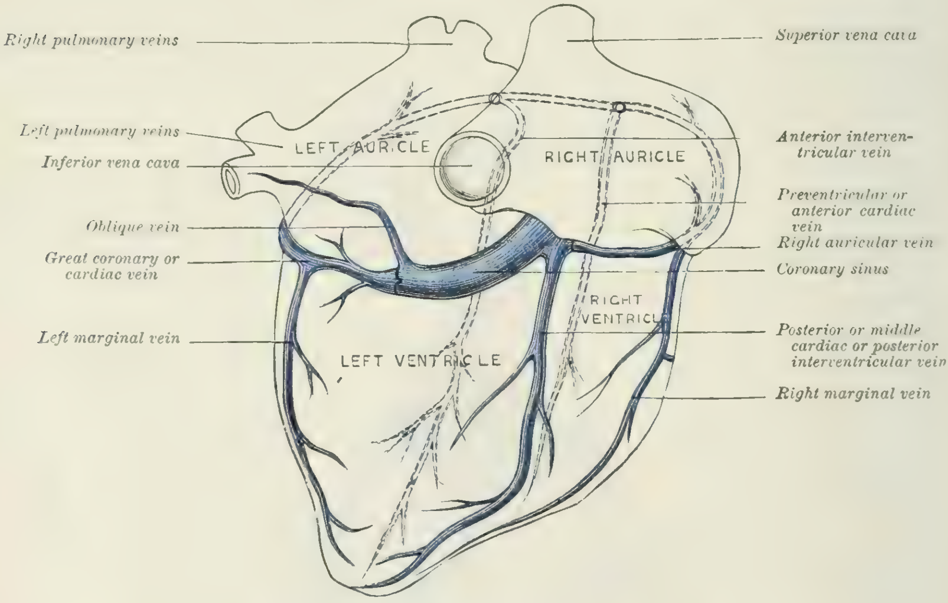

Right carotid artery
Left carotid artery
Innominate artery
Left subclavian artery
Aorta
Ductus arteriosus
Vena cava superior
Pulmonary artery
Left pulmonary veins
Right pulmonary veins
LEFT AURICLE
RIGHT AURICLE
Left coronary artery
Left marginal artery
Oblique vein of Marshall
Vena cava inferior
Left marginal vein
PERICARDIUM
Coronary sinus
Right coronary artery
Posterior cardiac vein
Posterior interventricular vein
Posterior interventricular branch of right coronary
Anterior interventricular branch of left coronary

The **coronary sinus** is situated at the back of the heart, in the groove between the left auricle and left ventricle. It measures about an inch in length. Its opening into the auricle is guarded by the so-called Thebesian or coronary valve. It receives the following tributaries: (1) The great coronary or cardiac vein, of which it appears to be the large and dilated end; (2) the posterior cardiac or posterior interventricular vein; (3) the right auricular vein; and (4) the oblique vein.

(1) The **great coronary** or **cardiac vein** is formed by the union of (*a*) the **anterior interventricular vein,** which runs upwards from the apex of the heart, in the groove between the right and left ventricles, in company with the artery of that name; with (*b*) the **left auricular vein,** which returns the blood from the left auricle. The vein thus formed then runs round the left side of the heart, in the groove between the left auricle and left ventricle, and terminates in the coronary sinus at the spot where the latter is joined by the oblique vein. Its entrance into the sinus is guarded by a double valve. It receives (*c*) the **left marginal vein** or veins, and branches from both ventricles, especially the left.

The **left marginal vein** runs with the artery of that name over the surface of the left ventricle, along the left margin of the heart. It receives tributaries from the left ventricle, and terminates in the great coronary vein.

FIG. 384.—SCHEME OF THE CORONARY VEINS. (Walsham.)


Right pulmonary veins
Left pulmonary veins
Inferior vena cava
Oblique vein
Great coronary or cardiac vein
Left marginal vein
Superior vena cava
Anterior interventricular vein
Preventricular or anterior cardiac vein
Right auricular vein
Coronary sinus
Posterior or middle cardiac or posterior interventricular vein
Right marginal vein
LEFT AURICLE
RIGHT AURICLE
RIGHT VENTRICLE
LEFT VENTRICLE

(2) The **posterior cardiac, middle cardiac,** or **posterior interventricular vein** accompanies the posterior interventricular artery upwards, from the apex of the heart in the posterior interventricular groove. It ends in the coronary sinus, just before the termination of the latter in the right auricle. It receives tributaries from the posterior surface of both ventricles, and is guarded by a valve where it joins the coronary sinus. Two or three small veins (posterior cardiac, or smaller posterior cardiac) run upwards from the back of the left ventricle, and open into the coronary sinus by separate orifices guarded by valves.

(3) The **right auricular, right coronary,** or **small coronary vein,** runs in the right auriculo-ventricular groove, and terminates in the coronary sinus just before the entrance of that sinus into the auricle. It is joined by the right marginal vein and by the preventricular or smaller anterior cardiac vein or veins.

(4) The **oblique vein**—the greater part of which is often represented merely by a delicate fibrous cord—runs across the back part of the left auricle, in the vestigial fold of the pericardium to the coronary sinus. This vein, with the coronary sinus,

its dilated portion, represents what was the left duct of Cuvier and part of the sinus venosus in the fœtus. As stated at page 605, it is occasionally found pervious, and may be greatly enlarged, and help to form the so-called left superior vena cava. There is, as might be gathered from the consideration of its morphology, no valve where the oblique vein is continued into the coronary sinus.

The **right marginal vein**—sometimes called the **anterior cardiac vein,** or **vein of Galen**—runs over the right ventricle, along the right margin of the heart, and opens either into the right auricular vein or separately into the lower part of the right auricle, its orifice, known as the foramen of Galen, being situated immediately below the opening of the superior vena cava. Other small veins—the **smaller anterior cardiac veins** (**venæ cordis parvæ,** or **preventricular veins**)—also track up from the anterior surface of the right ventricle, and open either into the right marginal vein or separately into the right auricle.

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2. *THE VEINS OF THE HEAD AND NECK*

The **veins of the head and neck** may be divided for purposes of description into the **superficial,** which return the blood from the external parts of the head and neck; and into the **deep,** which return the blood from the deeper structures. The **superficial** may be again subdivided, according to the region from which they carry the blood, into (1) The veins of the scalp and face; and (2) the veins of the neck. The **deep veins**—into which, moreover, some of the superficial open—may be subdivided into:—(1) The veins of the diploë; (2) the venous sinuses; (3) the veins of the brain; (4) the veins of the nasal cavities; (5) the veins of the ear; (6) the veins of the orbit; (7) the veins of the pharynx and larynx; and (8) the deep veins of the neck. All the veins, whether superficial or deep, sooner or later terminate in the internal jugular, the external jugular, the vertebral, or the deep cervical vein—chiefly the two former; and these veins open directly or indirectly into the innominate veins at the root of the neck, through which all the blood from the head and neck ultimately passes on its way to the heart. The external jugular vein is quite superficial; it is formed by the confluence of the veins corresponding to the upper branches of the external carotid artery, and, after receiving tributaries from the superficial parts of the neck and from the shoulder, terminates just above the clavicle in the subclavian vein. The internal jugular vein is deeply placed by the side of the common and internal carotid arteries. It begins in the jugular fossa, where it is continuous with the lateral sinus, and, after receiving tributaries corresponding to the lower branches of the external carotid artery, terminates at the root of the neck in the innominate vein. The vertebral vein accompanies the vertebral artery through the foramina in the transverse processes of the cervical vertebræ. It begins in the suboccipital triangle by the confluence of small veins from the deep muscles at the back of the occiput, and, after receiving tributaries from the cervical spine and deep muscles of the neck, ends in the innominate vein. The deep cervical receives the occipital vein, courses downwards amongst the deep muscles at the back of the neck, and ends in the innominate vein.

THE SUPERFICIAL VEINS OF THE HEAD AND NECK

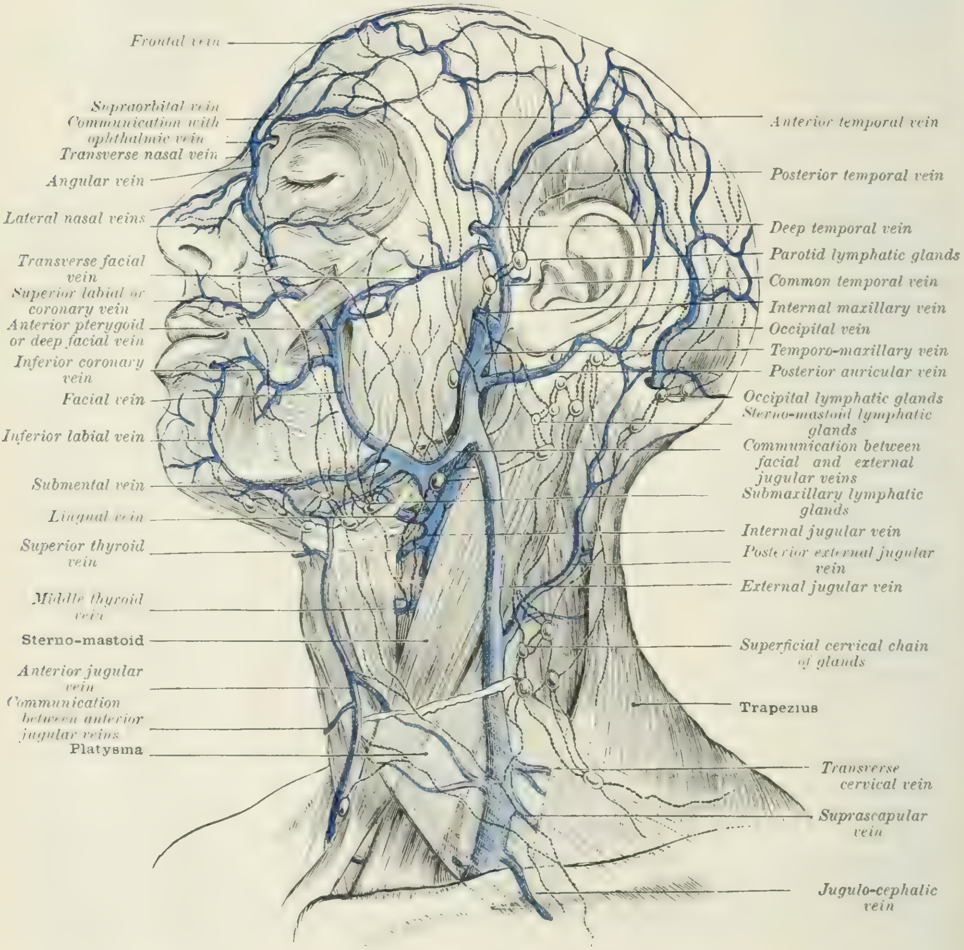
1. THE SUPERFICIAL VEINS OF THE SCALP AND FACE

The blood from the scalp is returned by three main channels—viz. an **anterior,** which passes over the forehead and face; a **posterior,** which descends over the occipital bone; and a **lateral,** formed by the confluence of two smaller veins which descend over the parietal and temporal bones respectively—one in front, and one behind the ear.

The Anterior Superficial Vein of the Scalp and Face

The **anterior vein** descends near the middle line, over the frontal bone, to the inner angle of the orbit; continues its course by the side of the nose to the cheek, which it crosses obliquely, to the anterior edge of the masseter muscle, and thence passes through the digastric triangle to the upper border of the hyoid bone, where it terminates in the internal jugular vein. In this course it is reinforced by numerous collateral veins, and gradually increases in size. It has, moreover, numerous communications with the deep veins.

Fig. 385.—The Superficial Veins and Lymphatics of the Scalp, Face, and Neck. (Walsham.)


Frontal vein
Supraorbital vein
Communication with ophthalmic vein
Transverse nasal vein
Angular vein
Lateral nasal veins
Transverse facial vein
Superior labial or coronary vein
Anterior pterygoid or deep facial vein
Inferior coronary vein
Facial vein
Inferior labial vein
Submental vein
Lingual vein
Superior thyroid vein
Middle thyroid vein
Sterno-mastoid
Anterior jugular vein
Communication between anterior jugular veins
Platysma
Anterior temporal vein
Posterior temporal vein
Deep temporal vein
Parotid lymphatic glands
Common temporal vein
Internal maxillary vein
Occipital vein
Temporo-maxillary vein
Posterior auricular vein
Occipital lymphatic glands
Sterno-mastoid lymphatic glands
Communication between facial and external jugular veins
Submaxillary lymphatic glands
Internal jugular vein
Posterior external jugular vein
External jugular vein
Superficial cervical chain of glands
Trapezius
Transverse cervical vein
Suprascapular vein
Jugulo-cephalic vein

This long continuous trunk vein is variously named according to the region in which it lies. Thus, as it descends over the frontal bone it is known as the **frontal vein**; as it lies by the side of the nose it is called the **angular vein**; whilst in the remainder of its course over the face and neck it is spoken of as the **facial vein.**

(1) The **frontal vein** begins about the level of the coronal suture in a venous plexus which communicates with the anterior division of the temporal vein. Soon forming a single trunk, it passes vertically downwards over the frontal bone, a short distance from the middle line and parallel to its fellow of the opposite side, to the inner canthus of the eyelids, where it takes the name of the angular vein (fig. 385).

Tributaries.—In its course it receives numerous tributaries from the forehead, and communicates freely with the vein of the opposite side, across the glabella or root of the nose, by a transverse branch sometimes called the **transverse nasal vein.** Just before its termination it receives the supraorbital vein. The transverse nasal vein usually receives the dorsal veins of the nose.

The **supraorbital vein** begins over the frontal eminences by intercommunications with the anterior branch of the superficial temporal vein. It receives tributaries from the forehead and eyebrow, and, running obliquely downwards and inwards, opens into the termination of the frontal vein. It communicates with the ophthalmic vein, and receives the frontal vein of the diploë as the latter vein issues from the bone at the bottom of the supraorbital notch.

(2) The **angular vein,** the continuation of the frontal vein downwards, extends from the junction of the frontal and supraorbital veins a little below the level of the eyebrow, to the level of the lower margin of the orbit, where it becomes the facial vein. In this short course it skirts round the inner margin of the orbit, lying with the angular artery on the nasal process of the superior maxillary bone a little internal to the lachrymal sac. Branches pass from the posterior part of the angular vein into the orbit to join the ophthalmic.

The angular, the facial, and the ophthalmic veins contain no valves. The blood, therefore, can pass either forward from the ophthalmic into the angular, or backwards through the facial and angular into the ophthalmic, and so on to the cavernous and other venous sinuses of the cranium. Hence in certain tumours in the orbit and cranium, the congestion of the angular and facial veins; and the danger in facial carbuncle and anthrax of septic thrombi spreading backwards through the angular and ophthalmic veins to the cranial sinuses.

Tributaries.—*(a)* The superior lateral nasal; and *(b)* the palpebral veins.

(a) The **superior lateral nasal veins** ascend from the ala and the side of the nose to join the inner side of the angular vein (fig. 385).

(b) The **palpebral veins** proceed from the upper and lower eyelids, and open into the outer side of the angular vein, either separately or by a common trunk. Several branches of the inferior palpebral vein open into the facial vein (fig. 385).

(3) The **facial vein,** the continuation of the angular, begins at the lower margin of the orbit, and, crossing the face obliquely downwards and outwards, passes at the anterior edge of the masseter muscle over the body of the lower jaw, and thence downwards and backwards across the digastric and superior carotid triangles to join the internal jugular vein about the level of the hyoid bone. It runs in a more or less direct line behind its corresponding artery, the facial, which itself pursues a tortuous course. It usually passes beneath the zygomatic muscles and beneath the platysma, but above the other muscles. At the anterior edge of the masseter it meets the facial artery, lying immediately posterior to it. In the neck it lies beneath the platysma and cervical fascia, and is usually separated from the facial artery by the submaxillary gland and the stylo-hyoid, and the posterior belly of the digastricus muscles, below which it frequently receives a communicating branch from the external jugular vein. That portion of the vein from the spot where it receives the communicating branch to its termination in the internal jugular is sometimes called the **common facial vein**; and the communicating branch, the **anterior division of the temporo-maxillary vein.** (See TEMPORO-MAXILLARY VEIN, page 616.)

Tributaries.—It receives on its **inner side,** from above downwards:—*(a)* The inferior lateral nasal veins; *(b)* the superior labial vein; *(c)* the inferior labial veins; *(d)* the submental vein; *(e)* the submaxillary veins. On its **outer side**:—*(a)* the inferior palpebral veins; *(b)* the anterior internal maxillary vein; *(c)* the buccal vein; *(d)* the anterior parotid vein; *(e)* the masseteric vein; and *(f)* the inferior palatine vein.

Communications.—It communicates with the infraorbital vein, the pterygoid plexus of veins, the anterior jugular vein, and the external jugular vein.

Tributaries on the Inner Side.—*(a)* The **inferior lateral nasal vein** is a small branch which corresponds with the lateralis nasi artery. It joins the facial on a level with the ala of the nose.

(b) The **superior labial** or **coronary vein** begins as a plexus in the orbicularis

oris muscle of the upper lip, and passes with the superior coronary artery outwards, and joins the facial vein a little below the level of the ala of the nose.

(*c*) The **inferior labial veins.**—A small branch (**inferior coronary**) usually opens into the facial a little below the superior labial vein; but the chief branch from the lower lip descends as a rule over the chin to the submental vein, and thus only opens indirectly into the facial vein. It may open into the anterior jugular vein.

(*d*) The **submental vein** lies on the mylo-hyoid muscle superficial to the submental artery. It begins below the chin, and, running backwards in the digastric triangle, joins the facial vein just after the latter has passed over the body of the lower jaw. It receives branches from the inferior labial plexus and the neighbouring muscles, and communicates with the anterior jugular vein.

(*e*) The **submaxillary** or **glandular veins** open into the facial as it crosses the submaxillary gland. But some branches from the gland often open into the submental vein.

Tributaries on the Outer Side.—(*a*) The **inferior palpebral veins.**—Several branches pass downwards to the facial vein; others, as before stated, pass inwards to the angular vein (page 613). Through one or more of these branches a communication is formed with the infraorbital vein.

(*b*) The **anterior internal maxillary vein,** sometimes known as the deep facial, passes downwards and forwards from the pterygoid plexus of veins between the buccinator and masseter muscles, and opens into the outer side of the facial vein under cover of the zygomaticus major muscle.

(*c*) The **buccal vein** is a small branch from the buccinator muscle.

(*d*) The **anterior parotid branch** descends from the glandula socia parotidis forwards to the facial.

(*e*) The **masseteric** is a small branch from the masseter muscle.

(*f*) The **inferior** or **descending palatine vein** accompanies the ascending palatine or tonsillar artery from the venous plexus about the tonsil and soft palate, and joins the facial vein just below the body of the lower jaw.

The **communicating branch** between the external jugular and facial veins—sometimes known as the **anterior division of the temporo-maxillary vein**—runs obliquely downwards and inwards from the external jugular vein from near the spot where the latter is continuous with the temporo-maxillary trunk. It joins the facial vein deeply just behind the angle of the jaw.

The **chief variations in the facial vein** are :—(1) It may run over the sterno-mastoid and open into the external jugular vein ; (2) it may open into the anterior jugular vein ; (3) it may run beneath the posterior belly of the digastricus and stylo-hyoid muscles ; (4) it may receive the lingual vein, the pharyngeal vein, or both of these veins.

The Posterior Superficial Vein of the Scalp

The **posterior vein** descends over the occipital bone, and then deeply amongst the muscles at the back of the neck. It ends in the innominate vein. The first or superficial portion of this trunk is known as the **occipital vein** ; the second or deeper portion as the **deep cervical vein** (fig. 385).

The **occipital vein** begins at the back of the skull in a venous plexus which anastomoses with the posterior auricular and posterior branch of the superficial temporal veins. It passes downwards over the occipital bone, and, perforating the trapezius with the occipital artery, sinks deeply into the suboccipital triangle, where it terminates in the deep cervical vein. At times it takes a more superficial course, and, joining the posterior auricular, passes with this into the external jugular vein. One of its branches—usually the outermost—receives an emissary vein issuing through the mastoid foramen of the temporal bone, and in this way forms a communication with the lateral sinus.

The **deep cervical vein** begins as a plexus of small veins in the suboccipital triangle. After receiving, as a rule, the occipital vein, it passes downwards between the complexus and the semispinalis colli, in company, first with the princeps cervicis branch of the occipital artery, and afterwards with the deep cervical branch of the superior intercostal artery. On reaching the transverse process of the seventh cervical vertebra, it turns forwards between that process and the neck of the first rib, and opens either directly into the innominate vein or into the vertebral immediately before that vein joins the innominate.

Tributaries.—It receives branches from the muscles amongst which it runs.

The Lateral Superficial Veins of the Scalp

The **lateral veins** descend, one in front and one behind the ear, and unite about the level of the angle of the jaw to form a single trunk—the external jugular vein.

The **anterior vein,** the larger of the two, is known as far as the zygoma as the **superficial temporal vein.** There it is joined by a deep vein from the temporal fossa—the **middle temporal vein**; and the united trunk, now called the **common temporal vein,** passes over the zygoma into the parotid gland. Opposite the neck of the lower jaw it receives the large **internal maxillary vein,** and takes the name of the **temporo-maxillary vein.** This emerges from the lower border of the parotid gland, and joins the posterior lateral vein, which is known as the **posterior auricular,** to form the external jugular vein.

The Anterior Lateral Veins.—The **superficial temporal vein** returns the blood from the parietal region of the scalp. It is formed by the union of an anterior and a posterior branch: the former communicates with the supraorbital and frontal veins; the latter with the posterior auricular and occipital veins and the temporal vein of the opposite side. These branches lie superficial to the corresponding branches of the superficial temporal artery, which they roughly though not accurately follow. Like the artery, they lie between the skin and the cranial aponeurosis, and descend over the temporal fascia to unite a little above the zygoma, and just in front of the pinna of the ear, to form the superficial temporal trunk. The vein thus formed continues its course downwards with the trunk of the temporal artery, and opposite the zygoma is joined by the middle temporal vein to form the common temporal vein.

The **middle temporal vein** corresponds with the middle temporal artery. It begins in a plexus in the temporal fossa, and then runs backwards between the layers of the temporal fascia, the outer layer of which it perforates near the zygoma, to join the superficial temporal vein. It receives an **orbital branch,** which corresponds with the orbital branch of the temporal artery, and communicates in front with the ophthalmic vein, the external palpebral veins, and the infraorbital veins, and then runs backwards between the layers of the temporal fascia to join the middle temporal trunk or plexus. The middle temporal vein communicates with the deep temporal veins, and through them with the pterygoid venous plexus.

The **common temporal vein,** formed by the confluence of the superficial and middle temporal veins, descends over the zygoma just in front of the pinna of the ear, lying a little superficial to the temporal artery. Then, passing deeply into the parotid gland, between the external auditory meatus and the angle of the jaw, it is joined almost at a right angle by the internal maxillary vein, and becomes the temporo-maxillary vein.

Tributaries.—It receives (*a*) the **transverse facial vein,** which corresponds to the transverse facial artery; (*b*) **articular veins** from the plexus around the temporo-mandibular joint—this plexus receives the **tympanic vein,** which, together with its corresponding artery, passes through the fissure of Glaser; (*c*) **parotid veins,** from the substance of the parotid gland; (*d*) **masseteric veins,** from the masseter muscle; and (*e*) **anterior auricular veins,** from the pinna of the ear.

The **internal maxillary vein** accompanies the first part of the internal maxillary artery between the internal lateral or spheno-mandibular ligament and the neck of the lower jaw. It begins at the posterior confluence of the veins forming the pterygoid plexus, and ends by uniting with the common temporal vein to form the temporo-maxillary trunk.

The **pterygoid plexus** is formed by the veins which correspond to the branches of the internal maxillary artery. It is situated, partly on the inner surface of the internal pterygoid muscle, and partly around the external pterygoid muscle. The veins entering into this plexus are:—the two **middle meningeal,** which accompany the artery of that name; the **posterior dental vein**; the **mandibular** (inferior dental); the **masseteric**; the **buccal**; the **pterygoid veins** from the pterygoid muscles; the **deep temporal,** by which the plexus communicates with the temporal plexus; the **spheno-palatine vein**; the **infraorbital**; the **superior palatine**; the lower branch of the **ophthalmic vein,** which courses through the spheno-maxillary fissure from the orbit; and the **Vesalian vein,** through which the plexus comunicates with the cavernous sinus. The plexus ends posteriorly in the internal maxillary vein which joins the common temporal vein, and anteriorly in the anterior internal maxillary or deep facial vein, which passes forwards and downwards between the buccinator and masseter muscles to join the facial vein.

The above-mentioned veins, forming by their confluence the pterygoid plexus, correspond in their course so nearly with that of their companion arteries, that a detailed description is not necessary. Although deeply placed, they are for convenience described with the superficial veins.

The **temporo-maxillary vein** is formed by the union of the common temporal vein and internal maxillary vein in the substance of the parotid gland. It usually joins about the angle of the jaw the posterior auricular vein to form the external jugular. At other times it divides into two branches, an anterior and a posterior. The anterior division runs forwards and downwards, and joins the facial vein (see FACIAL VEIN). The posterior division runs backwards over the sterno-mastoid and joins the posterior auricular to form the external jugular. When the temporo-maxillary trunk without dividing joins the posterior auricular to form the external jugular vein, the anterior branch is represented by the communicating branch between the external jugular and facial veins.

The Posterior Lateral Veins.—The **posterior auricular vein** begins in a venous plexus on the posterior part of the parietal bone. This plexus communicates with the vein of the opposite side, across the sagittal suture, and with the posterior branch of the superficial temporal vein in front, and with the occipital vein behind. It descends over the back part of the parietal bone and the mastoid process of the temporal bone, lying with its artery behind the ear. It then leaves the artery, and passing over the upper part of the sterno-mastoid muscle obliquely forwards and downwards, joins the temporo-mandibular vein about the level of the angle of the lower jaw, forming the external jugular vein (fig. 385).

Tributaries.—*(a)* Auricular veins from the back of the pinna; and *(b)* the stylo-mastoid vein, corresponding to the little stylo-mastoid artery. The latter vein opens into the posterior auricular vein, as a rule, as the latter leaves the mastoid process.

2. THE SUPERFICIAL VEINS OF THE NECK

The **external jugular vein** is formed by the confluence of the posterior auricular and temporo-maxillary veins near the angle of the lower jaw. It runs obliquely downwards and backwards across the sterno-mastoid muscle to a spot opposite the middle of the clavicle, where it terminates as a rule in the subclavian vein. A line drawn from a point midway between the mastoid process and angle of the jaw to the middle of the clavicle will indicate its course. It is covered by the skin, superficial fascia, and platysma, and is crossed by a few branches of the cervical plexus, the great auricular nerve running parallel to it at the upper part of the neck. It at first crosses the sterno-mastoid obliquely, then runs nearly parallel to the posterior border of that muscle, from which it is separated throughout its course by the anterior layer of the deep cervical fascia.

Just above the clavicle it perforates the cervical fascia, by which it is prevented from readily collapsing, the fascia being attached to its walls. It then opens into the subclavian vein; occasionally into the internal jugular, or into the confluence of the subclavian and internal jugular veins. It contains a pair of valves about one inch to two inches above the clavicle, and a second pair where it enters the subclavian vein. Both of these valves were shown by Sir James Struthers not to prevent the blood regurgitating, or injections passing from the larger vein into the external jugular.

Some anatomists describe the external jugular vein as being formed by the junction of the posterior auricular and occipital veins. The vein here regarded as the upper part of the trunk of the external jugular is looked upon by them merely as a branch of communication between the external jugular and temporo-maxillary vein.

The **chief variations of the external jugular vein** are:—(1) It may be very small, or much smaller or much larger than the opposite vein; (2) it may be wanting on one or both sides, the veins which normally form it then opening into the internal jugular; (3) it may be formed merely by the posterior auricular vein; (4) it may be perforated by the superficialis colli nerve; (5) it may receive the facial, the lingual, and the cephalic veins; (6) it may pass over the clavicle and open into the cephalic or subclavian vein.

Tributaries and communications.—From above downwards, the external jugular receives a branch from the internal jugular vein; the **posterior external jugular,** which in the fœtus was part of the primitive jugular vein; a large branch connecting it with the facial vein; one or two small branches of communication from the anterior jugular vein; near its termination, the **transverse cervical** and **suprascapular veins**; and sometimes the **anterior jugular vein** at the posterior border and hinder surface of the sterno-mastoid. At times the occipital vein opens into the external jugular, and is by some anatomists regarded as the normal termination of the former vein.

The **posterior external jugular vein** descends from the upper and back part of the neck, receiving small tributaries from the superficial structures and muscles. At times it communicates with the occipital, or may appear as a continuation of that vein. It opens into the external jugular as the latter vein is leaving the sterno-mastoid muscle. In the fœtus this vein returns the blood from the interior of the cranium through the post-glenoid foramen. Vestiges of the fœtal trunk are said to remain in the mastoid vein.

The **suprascapular veins,** two in number, correspond to the suprascapular artery. They usually form one trunk before they open into the external jugular vein. They contain well-marked valves.

The **transverse cervical veins**—or venæ comites of the transverse cervical artery—accompany that vessel and open with the suprascapular vein into the external jugular close to the spot where the latter vein joins the subclavian.

The **anterior jugular vein** begins below the chin by communicating with the mental, submental, inferior labial, and inferior hyoid veins. It descends a little external to the middle line, receiving branches from the superficial structures at the front and side of the neck, and occasionally a branch from the larynx and thyroid body. Just above the clavicle it turns outwards, and, piercing the fascia, passes beneath the sterno-mastoid muscle and opens into the external jugular vein just before the latter joins the subclavian; at times it opens into the subclavian vein itself. In its course down the neck it communicates with the external jugular; and, as it turns outwards beneath the sterno-mastoid, sends a branch across the trachea, between the layers of cervical fascia, to join the anterior jugular of the opposite side. This communicating vein may be divided in the operation of tracheotomy, and is then often found greatly engorged with blood. Another branch, often of considerable size, courses along the anterior margin of the sterno-mastoid and joins the facial vein. When the anterior jugular vein is large, the external jugular is small, and *vice versâ*. It is usually also of large size when the corresponding vein on the opposite side is absent, as is frequently the case. It contains no valves.

The position of the anterior jugular vein beneath the tendon of the sterno-mastoid should be borne in mind in tenotomy of that muscle for wry-neck.

THE DEEP VEINS OF THE HEAD AND NECK

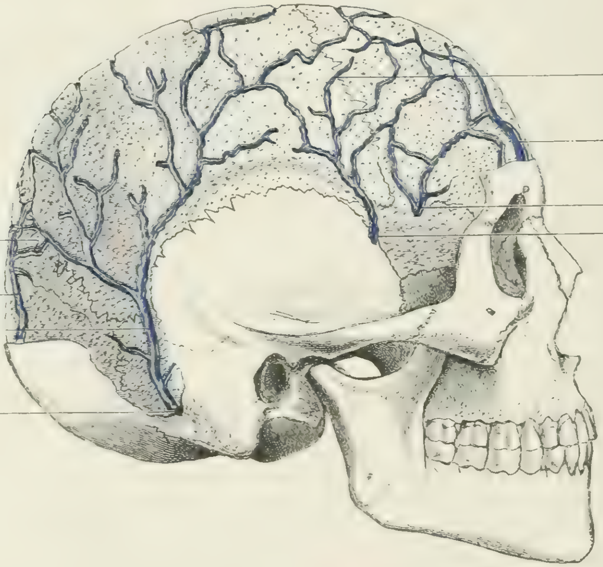
The **deep veins of the head and neck** may be divided into—1. the veins of the diploë; 2. the venous sinuses of the cranium; 3. the veins of the brain; 4. the veins of the nasal cavities; 5. the veins of the ear; 6. the veins of the orbit; 7. the veins of the pharynx and larynx; and 8. the deep veins of the neck. The veins of the diploë terminate partly in the superficial veins already described, partly in the venous sinuses of the cranium, and partly in the deep veins of the neck. The venous sinuses open into the deep veins of the neck. The veins of the brain terminate in the venous sinuses. The veins of the nasal cavities terminate partly in the deep, and to some extent in the superficial veins. The veins of the ear join both the superficial and deep veins and the venous sinuses. The veins of the orbit terminate partly in the superficial veins, but chiefly in the venous sinuses. The veins of the pharynx and larynx enter the deep veins of the neck.

1. THE VEINS OF THE DIPLOË

The **veins of the diploë** are contained in bony channels in the cancellous tissue between the external and internal tables of the skull. They are of comparatively large size, with very thin and imperfect walls, and form irregular communicating channels. They have no valves. They can only be seen on removing the external table of the skull with a file or chisel. They terminate in four or five main and descending channels, which open, some outwards through the external table of the skull into some of the superficial and deep veins of the head and face, and some inwards through the internal table into the venous sinuses. They are divided into the frontal, fronto-sphenoidal, fronto-parietal or anterior temporal, external parietal or posterior temporal, and occipital or parieto-occipital.

Fig. 386.—The Veins of the Diploë.

(From a specimen in St. Bartholomew's Hospital Museum.)


THE CORONAL SUTURE
The frontal diploic vein
The fronto-sphenoidal diploic vein
The fronto-parietal or anterior temporal diploic vein
THE LAMBDOID SUTURE
The occipital or parieto-occipital diploic vein
The external parietal or posterior temporal diploic vein
THE MASTOID FORAMEN

The **frontal** are contained in the anterior part of the frontal bone. They converge anteriorly to a single vein which passes downwards, perforates the external table through a small aperture in the roof of the supraorbital notch, and terminates in the supraorbital vein.

The **fronto-sphenoidal** are contained in the lateral parts of the frontal bone, and, running into the sphenoid bone, terminate in the sinus alæ parvæ.

The **fronto-parietal**, or **anterior temporal**, are contained in the posterior part of the frontal and in the anterior part of the parietal bone. They pass downwards, and end, partly in the deep temporal veins by perforating the greater wing of the sphenoid bone, and partly in the superior petrosal sinus.

The **external parietal**, or **posterior temporal**, ramifies in the parietal bone, and, coursing downwards to the posterior inferior angle of that bone, passes either through a foramen in its inner table, or through the mastoid foramen into the lateral sinus.

The **occipital,** or **parieto-occipital,** ramifies chiefly in the occipital bone, and opens into the occipital vein or into the lateral sinus.

The diploic veins freely anastomose with one another in the adult; but in the fœtus, before the bones have united, each system of veins is distinct.

2. THE VENOUS SINUSES OF THE CRANIUM

The **venous sinuses of the cranium** are endothelially lined blood-spaces, situated between the periosteal and meningeal layers of the dura mater. They are the channels by which the blood is conveyed from the cerebral veins, and from some of the veins of the meninges and diploë, into the veins of the neck. The sinuses of the base of the skull also carry the chief part of the blood from the orbit and eyeball to the jugular veins. At certain spots the sinuses communicate with the superficial veins by small vessels known as the emissary veins, which run through foramina in the cranial bones.

The venous sinuses are eighteen in number: six being disposed medianly and singly; six laterally and in pairs. The median and single sinuses are:—(1) the superior longitudinal; (2) the inferior longitudinal; (3) the straight; (4) the occipital; (5) the circular; and (6) the transverse or basilar. The lateral and paired sinuses are:—(7) the two lateral; (8) the two superior petrosal; (9) the two inferior petrosal; (10) the two cavernous; (11) the two spheno-parietal (sinus alæ parvæ), and (12) the two sigmoid—which latter, however, are usually described as part of the lateral. Occasionally there are two additional sinuses (the two **petro-squamous**), due to the persistence in the adult of what in the fœtus was the continuation of the lateral sinus.

(1) The **superior longitudinal sinus,** or **superior sagittal sinus** (fig. 388), lies in the median groove on the inner surface of the calvarium along the attached margin of the falx cerebri. It extends from the foramen cæcum to the internal occipital protuberance. It grooves from before backwards the frontal bone, the contiguous sagittal margin of the parietal bones, and the squamous portion of the occipital bone. In the fœtus it communicates, through the foramen cæcum, with the nasal veins, and generally throughout life with the superficial temporal vein through the parietal foramen. It is triangular on section, the base of the triangle corresponding to the bone. Crossing it are a number of fibrous bands known as the chordæ Willisii, and projecting into it in places are the Pacchionian bodies. In front the sinus is quite small, but it increases greatly in calibre as it runs backwards. It receives at intervals the superior cortical cerebral veins and the veins from the falx. The former, for the most part, open into it in the direction opposite to that in which the blood is flowing in the sinus. They pass for some distance in the walls of the sinus before opening into it. Posteriorly, at the internal occipital protuberance, the superior longitudinal sinus usually turns sharply to the right, and ends in the right lateral sinus; the straight sinus then usually terminates in the left lateral sinus, and the right and left lateral sinuses communicate with each other across the occipital protuberance. Occasionally, however, the superior longitudinal sinus ends in the left lateral sinus, the straight then passing into the right. At other times the posterior end of the superior longitudinal sinus at the internal occipital protuberance becomes slightly dilated, forming what is called the **torcular Herophili,** or confluence of the sinuses. When this dilatation exists, the straight sinus usually opens into it in front, the two lateral sinuses on either side, the superior longitudinal above, the occipital sinus or sinuses, when two are present, below. The torcular may communicate with the occipital vein through the occipital emissary vein, which, when present, passes through a minute foramen in the occipital protuberance.

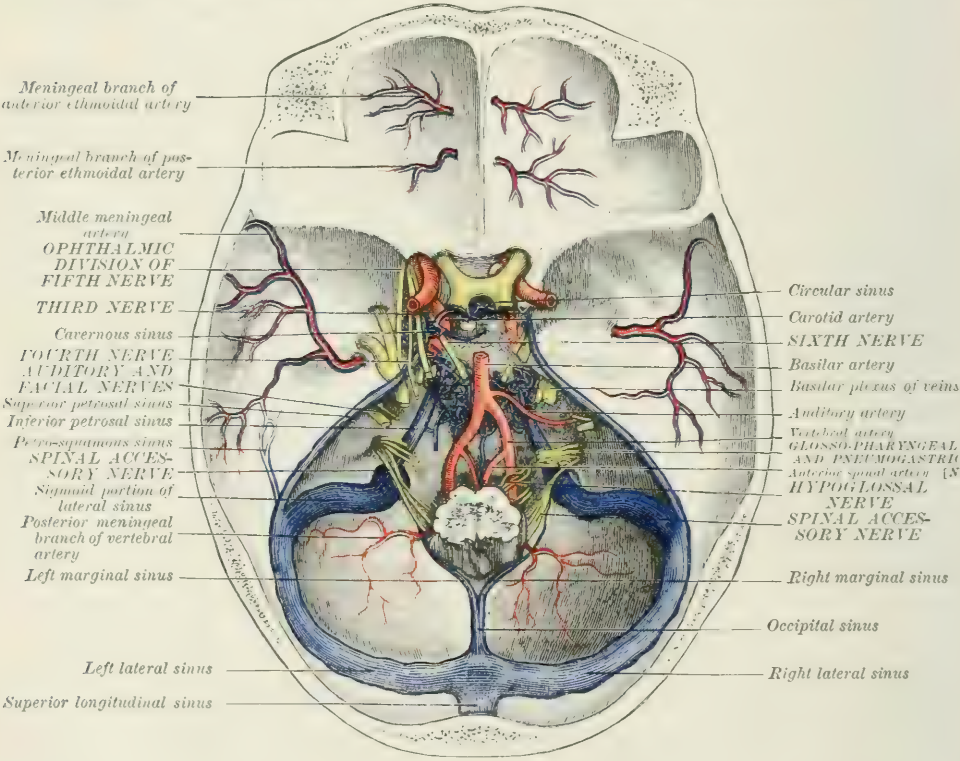
(2) The **inferior longitudinal** or **inferior sagittal sinus** (fig. 388) is situated at the free margin of the falx cerebri. Beginning about the junction of the anterior with the middle third of the falx, it is continued backwards along the concave or

lower margin of that process to the junction of the falx with the tentorium, where it ends in the straight sinus. The sinus is cylindrical in shape and of small size, and receives some of the inferior frontal veins of the brain, some of the veins from the median surface of the brain, and some of the veins of the falx.

(3) The **straight sinus,** or **sinus rectus** (fig. 388)—also variously called the sinus tentorii, perpendicularis, and obliquus—lies along the junction of the falx cerebri with the tentorium cerebelli. It is formed by the union of the great vein of Galen, from the velum interpositum, and the inferior longitudinal sinus. It receives in its course branches from the tentorium cerebelli and from the upper surface of the cerebellum. It runs downwards and backwards to the internal occipital protuberance, where it ends in the left lateral sinus, at times in the right lateral sinus, or in the torcular Herophili when that blood-space is present. On section it is triangular in shape, with its apex upwards.

FIG. 387.—THE VENOUS SINUSES.

(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)


Meningeal branch of anterior ethmoidal artery
Meningeal branch of posterior ethmoidal artery
Middle meningeal artery
OPHTHALMIC DIVISION OF FIFTH NERVE
THIRD NERVE
Cavernous sinus
FOURTH NERVE
AUDITORY AND FACIAL NERVES
Superior petrosal sinus
Inferior petrosal sinus
Petro-squamous sinus
SPINAL ACCESSORY NERVE
Sigmoid portion of lateral sinus
Posterior meningeal branch of vertebral artery
Left marginal sinus
Left lateral sinus
Superior longitudinal sinus
Circular sinus
Carotid artery
SIXTH NERVE
Basilar artery
Basilar plexus of veins
Auditory artery
Vertebral artery
GLOSSO-PHARYNGEAL AND PNEUMOGASTRIC [N.
Anterior spinal artery
HYPOGLOSSAL NERVE
SPINAL ACCESSORY NERVE
Right marginal sinus
Occipital sinus
Right lateral sinus

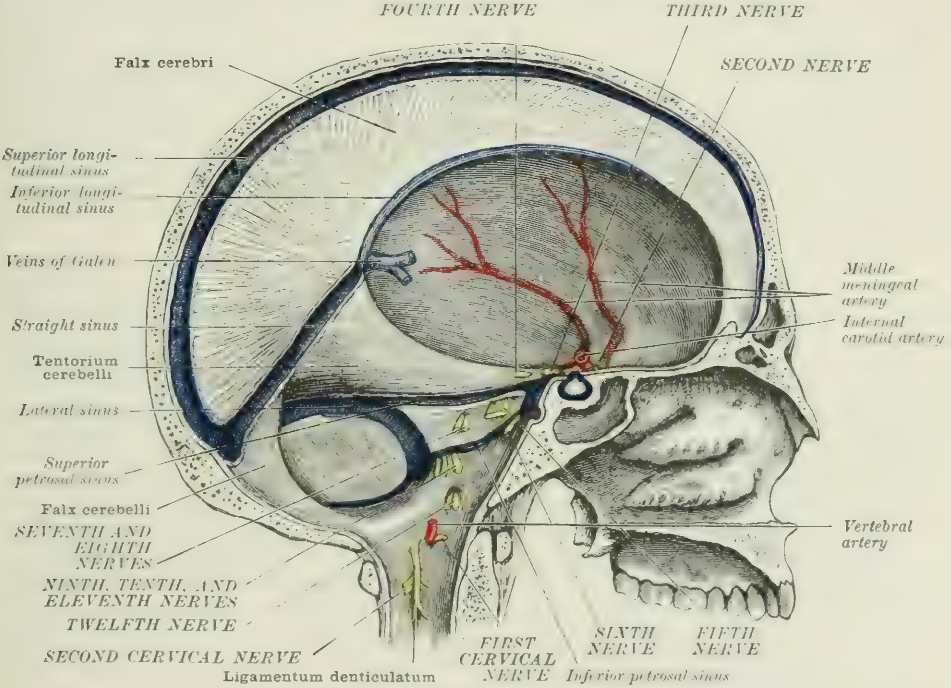
(4) The **occipital sinus** (fig. 387) ascends mesially at the attached margin of the falx cerebelli, along the lower half of the squamous portion of the occipital bone from near the posterior margin of the foramen magnum to the internal occipital protuberance. It usually begins in a right and a left branch, known as the **marginal sinuses.** These proceed from the termination of each lateral sinus, run round the foramen magnum, where they communicate with the posterior spinal veins, and unite at a variable distance from the internal occipital protuberance to form the single occipital sinus. Sometimes they remain separate as far as the occipital protuberance, then forming two occipital sinuses. One or other of the marginal sinuses may be much smaller than the other, or be entirely absent. At the point where the marginal sinuses unite to form the single occipital sinus, there is a communication with the posterior spinal veins. The occipital sinus ends either in one of the lateral sinuses, in the straight sinus, or in the torcular

Herophili when this is present. It receives in its course veins from the tentorium cerebelli, and from the inferior surface of the cerebellum. It communicates through the plexus of veins which surrounds the hypoglossal nerve in the anterior condyloid foramen with the vertebral vein and veins of the anterior spinal plexus.

(5) The **circular sinus,** so called (fig. 387), is a venous plexus encircling the hypophysis cerebri, and connecting the right and left cavernous sinuses. The more distinct channels are found, one in front of the sella turcica, one behind, and one on its floor, and are sometimes called the **anterior, posterior,** and **inferior intercavernous sinus,** the last being also known as the **inferior circular sinus of Winslow.**

(6) The **transverse** or **basilar sinus** (fig. 387) is a venous plexus in the substance of the dura mater over the basilar process of the occipital bone. It extends from the cavernous sinus to the margin of the foramen magnum below. It communicates laterally with the inferior petrosal sinus, and inferiorly with the anterior spinal veins. Through this sinus passes the sixth nerve. One of the larger of the irregular venous channels forming the sinus passes transversely from one inferior petrosal sinus to the other. It is this portion to which the description of the transverse sinus given by some authors appears to apply. This venous plexus on the basilar process is serially homologous with the anterior spinal plexus of veins on the posterior surface of the bodies of the vertebræ.

FIG. 388.—THE VENOUS SINUSES. (Longitudinal section.)


FOURTH NERVE
THIRD NERVE
Falx cerebri
SECOND NERVE
Superior longitudinal sinus
Inferior longitudinal sinus
Veins of Galen
Middle meningeal artery
Straight sinus
Internal carotid artery
Tentorium cerebelli
Lateral sinus
Superior petrosal sinus
Falx cerebelli
SEVENTH AND EIGHTH NERVES
Vertebral artery
NINTH, TENTH, AND ELEVENTH NERVES
TWELFTH NERVE
SECOND CERVICAL NERVE
FIRST CERVICAL NERVE
SIXTH NERVE
FIFTH NERVE
Ligamentum denticulatum
Inferior petrosal sinus

(7) The **lateral sinus** (fig. 387) extends from the internal occipital protuberance to the jugular foramen. In this course it lies in the groove (which has been named after it) along the squamous portion of the occipital bone, the posterior inferior angle of the parietal bone, the mastoid portion of the temporal bone, and the jugular process of the occipital bone. It at first runs horizontally outwards and forwards between the two layers of the tentorium cerebelli, following the curve of the groove on the occipital and the posterior inferior angle of the parietal bones. In this part of its course it is sometimes known as the **transverse sinus,** or lateral sinus proper, but on reaching the groove in the mastoid portion of the tem-

poral bone it leaves the tentorium and curves downwards and inwards and then forwards over the jugular process of the occipital bone, and ends in the posterior compartment of the jugular fossa in the **sinus jugularis** or bulb of the internal jugular vein. The **S**-shaped part of the sinus which lies on the mastoid portion of the temporal and jugular portion of the occipital bone is sometimes known as the **sigmoid sinus.** The lateral sinus receives the veins from the temporo-sphenoidal lobe of the cerebrum, some of the superior and inferior cerebellar veins, some of the veins of the medulla and pons, the occipital and the external parietal veins of the diploë, and at the spot where it leaves the tentorium the superior petrosal sinus and, when present, the petro-squamous sinus. It communicates with the occipital and vertebral veins through the mastoid and posterior condyloid foramina by means of emissary veins. As the lateral sinus lies between the layers of the tentorium it is on section prismatic in shape. The sigmoid portion is semicylindrical.

The **right** lateral sinus is usually the larger and the direct continuation of the superior longitudinal sinus, and hence conveys the chief part of the blood from the cortical surface of the brain and vault of the skull. The **left** lateral sinus is usually the smaller and the direct continuation of the straight sinus, and hence returns the chief part of the blood from the central ganglia of the brain.

The relation of the lateral sinus to the outside of the skull, especially to the mastoid process of the temporal bone, is of importance with reference to the operations of trephining the mastoid cells, opening the tympanum, and exposing the sinus itself, in septic thrombosis, &c. The course of the sinus corresponds to a line drawn from the external occipital protuberance to the base of the mastoid process, or to the asterion, and thence over the back of the mastoid process in a curved line towards its apex.

(8) The **superior petrosal sinus** (figs. 387, 388) runs at the attached margin of the tentorium cerebelli, along the upper border of the petrous portion of the temporal bone. It connects the cavernous with the lateral sinus. Leaving the outer and back part of the cavernous sinus just below the fourth nerve, it crosses the fifth nerve, and, after grooving the petrous bone, ends in the lateral sinus as the latter turns downwards on the mastoid portion of the temporal bone. It receives veins from the temporo-sphenoidal lobe of the cerebrum, veins from the cerebellum, veins from the tympanum through the squamo-petrosal fissure, and sometimes the fronto-parietal veins of the diploë.

(9) The **inferior petrosal sinus** (figs. 387, 388) runs along the line of the petro-occipital suture, and connects the cavernous sinus with the commencement of the internal jugular vein. It is shorter than the superior petrosal, but considerably wider. As it crosses the anterior compartment of the jugular foramen, it separates the glosso-pharyngeal from the pneumogastric and spinal accessory nerves. It receives veins from the inferior surface of the cerebellum, from the medulla and pons, and from the internal ear. The last issue through the aqueductus vestibuli and aqueductus cochleæ.

(10) The **cavernous sinus** (fig. 387) is an irregular shaped venous space situated between the meningeal and periosteal layers of the dura mater on the side of the body of the sphenoid bone. It extends from the central end of the sphenoidal fissure in front to the apex of the petrous bone behind. Its outer wall is the more distinct, and contains in it, but separated from the blood by the lining membrane of the sinus, the third and fourth nerves, and the ophthalmic division of the fifth nerve, the nerves lying in the above-mentioned order from above downwards, and from within outwards. The internal carotid artery and the sixth nerve also pass through the sinus, being separated from the blood by the endothelial lining. The inner wall is practically absent, the blood-space communicating across the middle line with the opposite sinus in front, behind, and below the pituitary body or hypophysis cerebri. (See CIRCULAR SINUS.) The cavernous sinus is traversed by numerous trabeculæ or fibrous bands, so that there is no central space, but rather a number of endothelially-lined irregular lacunar cavities communicating with each other. Hence its name cavernous, from its resemblance to cavernous tissue. **In front** it receives the ophthalmic vein, with which it is practically continuous, and just above the third nerve the sinus alæ parvæ.

Internally it communicates with the opposite sinus, and **posteriorly** it ends in the superior and inferior petrosal sinuses. It also receives veins from the inferior surface of the frontal lobe of the brain, and some of the middle cerebral veins. Through the Vesalian vein, which runs in a minute foramen in the spinous process of the sphenoid bone, the sinus communicates with the pterygoid plexus of veins; through the venous plexus around the intraosseous portion of the internal carotid, with the internal jugular vein; and through small veins which leave the cranium by the foramen ovale and foramen lacerum medium, with the pterygoid and pharyngeal plexuses.

(11) The **spheno-parietal sinus,** or **sinus alæ parvæ,** runs in a slight groove on the under surface of the lesser wing of the sphenoid bone. It originates in one of the meningeal veins near the apex of the lesser wing, and, running inwards, passes through the sphenoidal fold of dura mater above the third nerve into the front part of the cavernous sinus. It generally receives the fronto-sphenoidal veins from the diploë.

The **petro-squamous sinus** is occasionally present. It lies in a groove along the junction of the petrous and squamous portions of the temporal bone. It opens posteriorly into the lateral sinus at the spot where the latter enters on its sigmoid course. In front it sometimes, though very rarely, passes through a foramen in the squamous portion of the temporal bone between the glenoid cavity and the external auditory meatus into the temporal vein. This sinus is the rudiment of what in early fœtal life, before the development of the internal jugular vein, was the continuation of the lateral sinus, the blood from the interior of the skull at this period passing through the above-mentioned foramen into the primitive jugular vein.

3. THE VEINS OF THE BRAIN

The **veins of the brain** present the following peculiarities:—(*a*) They do not accompany the cerebral arteries. (*b*) Ascending veins do not as in other situations run with descending arteries, but with ascending arteries, and *vice versâ*. (*c*) The deep veins do not freely communicate. (*d*) The veins have very thin walls, no muscular coat, and no valves. (*e*) The veins opening into the longitudinal, and some of those opening into the lateral sinus pour in their blood in a direction opposite to the current in the sinuses, so impeding the flow in both vein and sinus. (*f*) The flow of blood in the sinuses is further retarded by the trabeculæ stretching across their lumen, and in the longitudinal sinus by the blood having to ascend, when the body is erect, through the anterior half of its course.

The veins of the brain may be divided into the **cerebral** and the **cerebellar.**

The Cerebral Veins

The **cerebral veins,** like the cerebral arteries, may be divided into the **cortical** or **hemispheral,** and the **central** or **ganglionic.**

The **cortical, hemispheral** or **superficial veins** ramify on the surface of the brain and return the blood from the cortical substance into the venous sinuses. They lie for the most part in the sulci between the convolutions, but some pass over the convolutions from one sulcus to another. They consist of two sets: a superior and an inferior.

(1) The **superior cortical veins,** some eight to twelve in number on each side, are formed by the union of branches from the convex and median surfaces of the cerebrum. Those from the convex surface pass forwards and inwards towards the longitudinal fissure, where they are joined by the branches coming from the median surface. After receiving a sheath from the arachnoid, they enter obliquely into the superior longitudinal sinus, running for some distance in its walls. These veins freely communicate with each other, thus differing from the cortical arteries. They also communicate with the inferior cortical veins. They may be roughly divided into (*a*) frontal; (*b*) paracentral; (*c*) central; and (*d*) occipital.

(2) The **inferior cortical veins** ramify on the base of the hemisphere and the lower part of its outer surface. Those on the inferior surface of the frontal lobe

pass, in part into the inferior longitudinal sinus, and in part into the cavernous sinus. Those on the temporo-sphenoidal lobe enter in part into the superior petrosal sinus, and in part into the lateral sinus, passing into the latter from before backwards. A large vein from the occipital lobe winds over the crus cerebri and joins the great vein of Galen just before the latter enters the straight sinus. One of the inferior cortical veins is sometimes called the middle cerebral vein; another the great anastomosing vein of Trolard; another the posterior anastomosing vein of Labbé. The first ramifies over the under surface of the frontal and temporo-sphenoidal lobes, and at the anterior and lower part of the fissure of Sylvius opens into the cavernous sinus. The second establishes a communication between the superior longitudinal and cavernous sinuses by anastomosing with the middle cerebral and one of the superior cortical veins. The third passes from the middle cerebral vein over the temporo-sphenoidal lobe to the lateral sinus.

The **central, ganglionic,** or **deep cerebral veins** are collected into two large venous trunks, the venæ Galeni, which leave the brain at the great transverse fissure, that is, between the splenium of the corpus callosum and the optic lobes. At this spot they unite to form a single vein, the **vena magna Galeni,** which opens into the anterior end of the straight sinus. The venæ Galeni are formed by the union of the choroid vein with the vena corporis striati near the foramen of Monro. From this spot they run backwards parallel to each other between the layers of the velum interpositum, and terminate in the way above mentioned.

Tributaries of the veins of Galen.—The choroid vein, the vein of the corpus striatum, the basilar vein, the veins of the optic thalamus, the vein of the choroid plexus of the third ventricle, and veins from the corpus callosum, the pineal body, the optic lobes, and posterior horn of the lateral ventricle. The united trunk, or great vein of Galen, receives veins from the upper surface of the cerebellum, and one of the posterior inferior cerebral veins.

The **choroid vein** runs with the choroid plexus. It begins in the inferior cornu of the lateral ventricle, and ascends on the outer side of the choroid plexus along the margin of the velum interpositum to the foramen of Monro, where it unites with the vein of the corpus striatum to form the vein of Galen. It receives tributaries from the hippocampus major, corpus callosum, and fornix.

The **vena corporis striati,** formed by veins from the corpus striatum and optic thalamus, runs forwards in the groove between those structures, passing in its course beneath the tænia semicircularis, and joins the vein of Galen at the foramen of Monro. **Tributaries.**—It receives, in addition to the veins from the corpus striatum and optic thalamus, small veins from the fornix, septum lucidum, and anterior cornu of the lateral ventricle.

The **basilar vein,** formed by the confluence of the deep Sylvian vein, the inferior striate veins, and some small anterior cerebral veins, runs backwards over the crus cerebri, and enters the vein of Galen near the union of that vessel with the vein of the opposite side. **Tributaries.**—The deep Sylvian vein from the insula and surrounding convolutions; the inferior striate veins from the corpus striatum, which they leave through the anterior perforated space; anterior cerebral veins from the front of the corpus callosum; interpeduncular veins from the structures in the interpeduncular space; ventricular veins from the middle cornu of the lateral ventricle; and mesencephalic veins from the mid-brain.

The Cerebellar Veins

The **cerebellar veins** are divided into the **superior** and **inferior.**

The **superior** ramify on the upper surface of the cerebellum; some of them run inwards over the superior vermiform process to join the straight sinus and great vein of Galen; others run outwards to the lateral and superior petrosal sinuses.

The **inferior,** larger than the superior, run, some forwards and outwards to the inferior petrosal and lateral sinuses, and others directly backwards to the occipital sinuses.

THE VEINS OF THE MEDULLA AND PONS

The veins from the **medulla oblongata** and the **pons** terminate in the inferior petrosal and lateral sinuses.

4. THE VEINS OF THE NASAL CAVITIES

The venous plexuses on the inferior turbinated bone and back of the septum are described with the NOSE. The veins leaving the nasal cavities follow roughly the course of their corresponding arteries. Thus the spheno-palatine veins pass through the spheno-palatine foramen into the pterygoid plexus; the anterior and posterior ethmoidal veins join the ophthalmic. Small veins accompany branches of the facial artery through the nasal bones and nasal processes of the superior maxillary bones, and end in the angular and facial veins; and other small veins pass from the nose anteriorly into the superior labial, and thence to the facial.

5. THE VEINS OF THE EAR

The veins from the external ear and external auditory meatus join the temporal and posterior auricular veins. The veins from the tympanum open into the superior petrosal sinus and temporo-maxillary vein. The blood from the labyrinth flows chiefly through the internal auditory veins which lie with the internal auditory artery in the internal auditory meatus, and enters the inferior petrosal or lateral sinus. Some of the blood from the labyrinth, however, passes through the vestibular vein which lies in the aqueductus vestibuli, into the inferior petrosal sinus, and some through the aqueductus cochleæ, into the commencement of the internal jugular vein.

6. THE VEINS OF THE ORBIT

The blood from the eyeball and orbit is returned by the ophthalmic vein into the cavernous sinus. This vein and its tributaries have no valves, and communicate in front with the frontal, supraorbital, and other veins. Hence under certain conditions, as from pressure on the cavernous sinus, the blood may flow in the contrary direction to the normal—i.e. from behind forwards into the frontal and supraorbital, and thence through the angular vein into the facial. In this way pressure on the retinal veins is quickly relieved, and little or no distension occurs in cases of obstruction in the cavernous sinus.

The **ophthalmic vein,** or **common ophthalmic vein,** is formed by the confluence at the back of the orbit of the superior and inferior ophthalmic veins. It is a short thick trunk, and passes backwards between the two heads of the external rectus muscle below the sixth nerve, and at the inner part of the sphenoidal fissure leaves the orbit and enters the front part of the cavernous sinus.

A. The **superior ophthalmic vein,** larger than the inferior, begins at the inner canthus of the eyelid by a free communication with the frontal, supraorbital, and angular veins, and thence runs backwards and outwards with the ophthalmic artery across the optic nerve to the inner end of the sphenoidal fissure, where it joins the inferior ophthalmic vein to form the common ophthalmic trunk. In this course it lies anterior and superficial to the ophthalmic artery.

Tributaries.—(1) The superior muscular veins; (2) the ciliary veins; (3) the anterior and posterior ethmoidal veins; (4) the lachrymal vein; and (5) the central vein of the retina.

(1) The **superior muscular branches** are derived from the levator palpebræ, superior rectus, superior oblique, and internal rectus.

(2) The **ciliary veins** are divided into two sets: an **anterior,** which emerge from the eyeball with the anterior ciliary arteries, and open into the muscular veins returning the blood from the four recti; and a **posterior set,** known as the venæ vor-

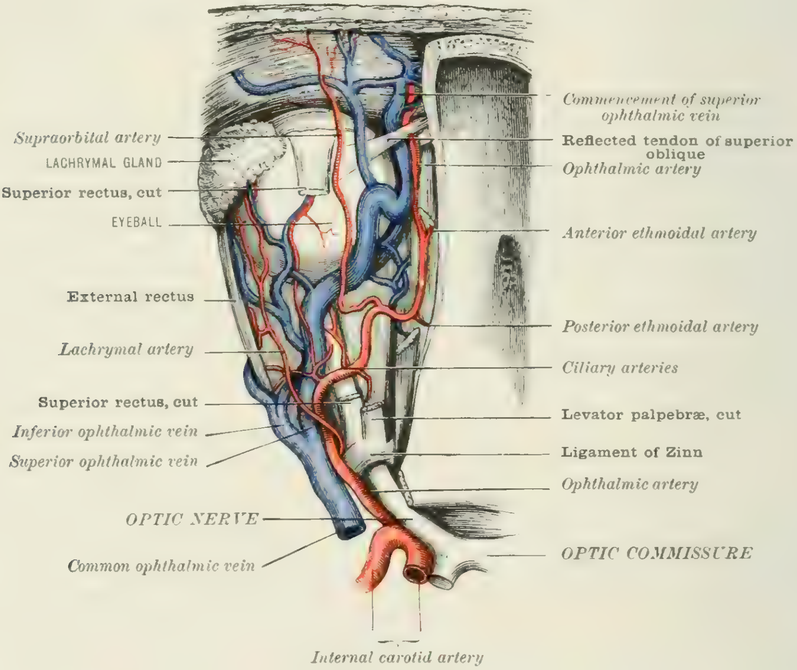
ticosæ, which leave the globe midway between the cornea and entrance of the optic nerve. The latter veins are four or five in number, the upper ending in the superior, the lower in the inferior ophthalmic vein (page 852).

(3) The **anterior and posterior ethmoidal veins** correspond in their course with the arteries of the same name. They enter the orbit through the anterior and posterior ethmoidal foramina, and join either the ophthalmic direct, or one or other of the superior muscular branches.

(4) The **lachrymal vein** returns the blood from the lachrymal gland, and corresponds in its course to the lachrymal artery.

(5) The **central vein of the retina** runs with the central artery in the optic nerve. It joins the superior ophthalmic at the back of the orbit.

Fig. 389.—The Veins of the Orbit.


Commencement of superior ophthalmic vein
Supraorbital artery
Reflected tendon of superior oblique
LACHRYMAL GLAND
Ophthalmic artery
Superior rectus, cut
EYEBALL
Anterior ethmoidal artery
External rectus
Posterior ethmoidal artery
Lachrymal artery
Ciliary arteries
Superior rectus, cut
Levator palpebræ, cut
Inferior ophthalmic vein
Ligament of Zinn
Superior ophthalmic vein
Ophthalmic artery
OPTIC NERVE
Common ophthalmic vein
OPTIC COMMISSURE
Internal carotid artery

B. The **inferior ophthalmic vein**, smaller than the superior, is formed near the front of the orbit by the confluence of the inferior muscular with the lower posterior ciliary veins. It runs backwards below the optic nerve, along the floor of the orbit, and either joins the superior ophthalmic vein to form the common ophthalmic trunk, or else opens separately into the cavernous sinus. A large communicating branch passes downwards through the spheno-maxillary fissure to join the pterygoid plexus of veins.

Tributaries.—(1) The **inferior muscular**, which are derived from the inferior oblique, inferior rectus, and external rectus; and (2) the **lower posterior ciliary veins.**

7. THE VEINS OF THE PHARYNX AND LARYNX

The **veins of the pharynx** are arranged in the form of a plexus, between the constrictor muscles and the pharyngeal or prevertebral fascia. The plexus receives branches from the mucous membrane, from the soft palate, the Eustachian tube, and the anterior recti and longus colli muscles. Above, it communicates with the pterygoid plexus of veins; below, either with the lower end of the facial vein, or with the internal jugular vein.

The **veins of the larynx** end partly in the superior, and partly in the inferior thyroid veins.

8. THE DEEP VEINS OF THE NECK

The **deep veins of the neck** are the internal jugular vein, the vertebral vein, and the deep cervical vein and their respective tributaries.

The Internal Jugular Vein

The **internal jugular vein** begins at the jugular fossa, and is the continuation of the lateral sinus. It passes down the neck in company first with the internal carotid artery, and then with the common carotid artery to a spot a little external to the sterno-clavicular articulation, where it joins the subclavian to form the innominate vein. At its commencement in the larger, and posterior and external part of the jugular foramen, it is somewhat dilated, forming the so-called **bulb** or **sinus** of the internal jugular vein. This dilated part of the internal jugular vein lies in the jugular fossa of the temporal bone and is therefore in immediate relation to the floor of the tympanum. At first the internal jugular lies in front of the rectus capitis lateralis, and behind the internal carotid artery, from which it is separated by the hypoglossal, glosso-pharyngeal, and pneumogastric nerves, and by the carotid plexus of the sympathetic. But as it descends it passes gradually to the outer side of that vessel, and retains this relation as far as the upper border of the thyroid cartilage. Thence it runs to its termination along the outer side of the common carotid artery, being contained in the same sheath with it and the pneumogastric nerve, but separated from these structures by a distinct septum. The vein generally overlaps the artery in front; hence the importance in tying the carotid of opening the sheath well to the inner side of that vessel, in order to avoid the vein. About an inch above its termination it contains a pair of imperfect valves.

Tributaries.—At the bulb or sinus the internal jugular vein receives the inferior petrosal sinus; opposite the angle of the jaw veins from the pharyngeal plexus, and often a communicating branch from the external jugular vein; opposite the bifurcation of the carotid it is joined by the facial, and a little lower down by the lingual and the superior thyroid vein, and at the level of the cricoid cartilage by the middle thyroid vein.

The inferior petrosal sinus is described with the other sinuses of the brain (page 622); the pharyngeal plexus with the veins of the pharynx (see above); and the facial vein with the superficial veins of the scalp and face (page 613).

The **lingual vein** begins near the tip of the tongue, under the name of the ranine. It lies at first close to the hypoglossal nerve and beneath the mucous membrane covering the under surface of the tongue. It then passes backwards across the hyo-glossus where this muscle forms the floor of Lesser's triangle, the latter muscle intervening between it and the lingual artery. After receiving the sublingual vein and the dorsalis linguae veins which roughly correspond to their respective arteries, and the two small veins (venae comites) which frequently accompany the lingual artery beneath the hyo-glossus, the united trunk crosses the common carotid artery and opens into the internal jugular vein. At times these tributaries open separately into the internal jugular vein or into the facial vein.

The **superior thyroid vein** emerges from the upper part of the thyroid body, in which it freely anastomoses with the other thyroid veins, both in the substance of the organ, and on its surface beneath the capsule. Thence it passes upwards and outwards into the internal jugular vein, crossing the common carotid artery in its course. At times it forms a common trunk with the facial vein. Its **tributaries** are the sterno-hyoid, sterno-thyroid, and thyro-hyoid veins from the muscles bearing those names; and the crico-thyroid and superior laryngeal vein, which correspond with the crico-thyroid and superior laryngeal arteries respectively. These require no special description.

The **middle thyroid vein** passes out from the capsule of the thyroid gland near the lower part of the lateral lobe of that body, crosses the common carotid obliquely downwards and outwards, and opens into the internal jugular vein a little below the cricoid cartilage.

THE INFERIOR THYROID VEINS

The **inferior thyroid veins** descend from the lower part of the thyroid body obliquely outwards to the innominate veins. The **right vein** crosses the innominate artery just before its bifurcation, and ends in the right innominate vein a little above the superior vena cava. It receives inferior laryngeal veins and veins from the trachea, and has valves at its termination in the innominate. The **left vein** passes obliquely over the trachea behind the sterno-thyroid muscle, and opens into the left innominate vein. It also receives laryngeal and tracheal veins, and is guarded by valves where it opens into the innominate trunk. The inferior thyroid veins communicate across the trachea by transverse branches. Not unfrequently the inferior thyroid veins (right and left) unite to form a single trunk which joins the left innominate vein.

THE VERTEBRAL VEINS

The **vertebral vein** (fig. 342) does not accompany the vertebral artery in its fourth stage, that is, within the skull, but begins as a plexus of small veins in the suboccipital triangle. It then enters the foramen in the transverse process of the atlas, and passes with the vertebral artery through the foramina in the transverse processes of the cervical vertebræ, forming a plexus around the artery. On leaving the transverse process of the sixth cervical vertebra it crosses in front of the subclavian artery and opens into the innominate vein. It has one or two semilunar valves at its entrance into the innominate vein. In the suboccipital triangle it communicates with the intraspinal, deep cervical, and occipital veins, and is joined by veins from the recti and oblique muscles and the pericranium. **Tributaries.**—As it passes down the neck it receives (1) lateral spinal veins, which issue along with the cervical nerves and lateral spinal arteries from the spinal canal; (2) branches from the venous plexus about the bodies of the cervical vertebræ and their transverse processes; (3) branches from the deep cervical muscles; and (4) branches from the cervical dorsal spinal veins. Just before it terminates in the innominate it is joined by (5) the deep cervical vein (sometimes); (6) the anterior vertebral vein; and (7) the upper superior intercostal vein (sometimes).

The **anterior vertebral vein** begins in a plexus in front of the bodies of the cervical vertebræ, and, running downwards with the ascending cervical artery between the scalenus anticus and longus colli muscles, opens into the vertebral vein just before the latter ends in the innominate. It receives tributaries from the scaleni, longus colli, and rectus capitis anticus muscles.

The **deep cervical vein,** which is really a part of the posterior superficial vein of the scalp, is described with that vein (page 614).

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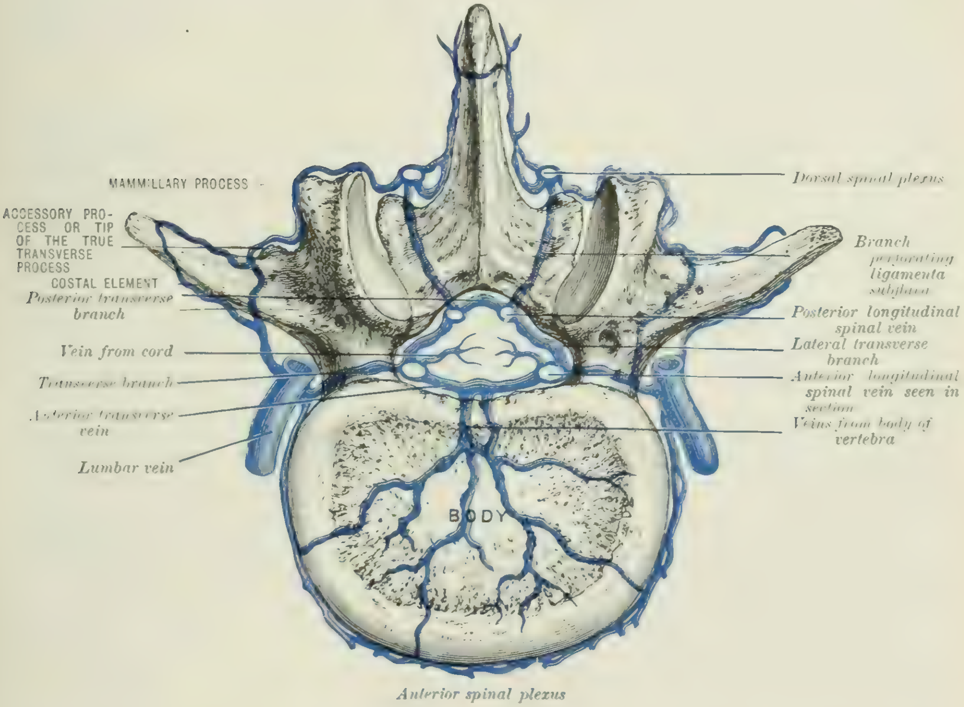
3. *THE SPINAL VEINS*

The **spinal veins,** which form plexuses around and within the spinal canal from the cranium to the sacrum, may be divided into the extra- and intraspinal veins. The **extraspinal** form a plexus both in front of the bodies of the vertebræ (the **anterior spinal plexus**), and in the spinal groove between the transverse and spinous processes—the **dorsal plexus, or dorsal spinal plexus** as it is often called. The **intraspinal veins,** or those within the spinal canal, may be divided into the meningeal and the medullary. The **meningeal** form an anterior and a posterior spinal plexus between the dura mater and the walls of the spinal canal, and are generally known as the **meningo-rachidean veins.** They receive the veins from the bodies of the vertebræ. The **medullary set** are situated within the dura mater; they return the blood from the spinal cord, and are known as the medullispinal veins.

1. **The extraspinal veins.**—(*a*) The veins of the **anterior spinal plexus** ramify in front of the bodies of the vertebræ. They are of small size and most distinct in the cervical region (fig. 390). They open into the neighbouring veins.

(*b*) The veins of the **posterior spinal** or **dorsal spinal plexus** are situated around the spinous processes, the laminæ, and the articular and transverse processes of the vertebræ, the larger veins of the plexus running horizontally forwards along the interspinous ligaments. The plexus is formed chiefly by the union of tributaries proceeding from the integuments of the back and the spinal muscles.

FIG. 390.—THE SPINAL VEINS.


MAMMILLARY PROCESS
ACCESSORY PROCESS OR TIP OF THE TRUE TRANSVERSE PROCESS
COSTAL ELEMENT
Posterior transverse branch
Vein from cord
Transverse branch
Anterior transverse vein
Lumbar vein
Dorsal spinal plexus
Branch perforating ligamenta subflava
Posterior longitudinal spinal vein
Lateral transverse branch
Anterior longitudinal spinal vein seen in section
Veins from body of vertebra
BODY
Anterior spinal plexus

Communications take place between the veins of each vertebral segment by vertical branches running upwards and downwards to the plexus above and below respectively near the base of the transverse processes. Branches are also sent through the ligamenta subflava between the laminæ of the several vertebræ to the posterior plexus of the intraspinal veins, and also forwards between the transverse processes of the vertebræ to join the vertebral vein in the neck, the dorsal branch of the intercostal veins in the thorax, the lumbar veins in the lumbar region, and the lateral sacral veins in the sacral region.

2. The **intraspinal veins** are divided into (*a*) the **meningeal**; and (*b*) the **medullary, or medulli-spinal.**

(*a*) The **meningeal extra-medullary** or **meningo-rachidian veins** lie in the fatty tissue between the walls of the vertebral canal and the dura mater or theca vertebralis. They are arranged in four longitudinal channels, two of which are anterior and two posterior, united by transverse branches corresponding in number to the vertebral segments (fig. 390).

The **anterior longitudinal spinal veins** extend from the foramen magnum to the coccyx as two tortuous plexiform vessels, one being placed on each side of the back of the bodies of the vertebræ behind the posterior common ligament. Opposite the body of each vertebra they communicate by a transverse branch, which passes between the body of the vertebra and posterior common ligament, an arrangement which is sometimes spoken of as the spinal venous ladder. Each transverse branch as it lies under cover of the posterior common ligament receives the veins from the bodies of the vertebræ (the **venæ basis vertebræ**). At the spot where each longitudinal vein is joined by the transverse branch, the vessel becomes considerably dilated. From the longitudinal vein branches run backwards to join the posterior longitudinal veins, and opposite the intervertebral foramina a transverse branch runs outwards to join the vertebral vein, the intercostal veins, the lumbar veins, and the sacral veins, according to the region of the spine in which the vertebra is situated. Above, the anterior spinal veins communicate with the basilar plexus at the front of the foramen magnum.

The **posterior longitudinal spinal veins,** smaller than the anterior longitudinal veins, likewise extend from the cranium to the coccyx. They lie between the posterior wall of the spinal canal and the dura mater. Like the anterior, they communicate by transverse branches, which receive veins through the ligamenta subflava from the dorsal spinal plexus. They also communicate with the anterior longitudinal veins by lateral transverse branches.

It will be thus seen (fig. 390) that in the interior of the vertebral canal, opposite each vertebral segment, there is a venous ring between the bony wall of the canal and the sheath of the dura mater, the ring being formed in front by the anterior transverse vein; on each side by the dilated portion of the trunk of the anterior longitudinal spinal vein, and the lateral transverse branch; and behind, by the trunk of the posterior longitudinal vein and the posterior transverse branch. This venous ring receives veins from the body of the vertebra, from the spinal cord, and from the meninges, and pours its blood, in part through the lateral veins lying in the intervertebral foramina into the vertebral, intercostal, lumbar, or sacral veins; and in part through the branch which perforates the ligamenta subflava into the dorsal spinal plexus. Above, the posterior longitudinal veins communicate at the back of the foramen magnum with the occipital sinuses. Around the foramen magnum a distinct venous ring or plexus is formed by the communication between the occipital and marginal sinuses and the posterior and anterior spinal veins.

(*b*) The **medullary** or **medulli-spinal veins,** or veins of the spinal cord, are of small size, and run in the pia mater in a tortuous course along the spinal cord. They join the venous ring corresponding to each vertebral segment by passing along the sheath of dura mater reflected round the spinal nerves.

4. *THE VEINS OF THE ABDOMEN AND PELVIS*

All the veins of the abdomen and pelvis—with the exception of the superior epigastric vein and ascending lumbar vein, which open ultimately into the superior vena cava—enter directly or indirectly into the inferior vena cava. The veins corresponding to the parietal branches of the abdominal aorta, except the middle sacral vein, open directly into the inferior vena cava; the middle sacral vein only indirectly through the left common iliac vein. Of the visceral veins corresponding to the visceral branches of the abdominal aorta, those which return the blood from the stomach, intestines, and pancreas (the chylopoetic viscera), and from the spleen, end in a common trunk (the **portal vein**). The portal vein enters the liver, and breaks up in the liver substance into capillaries like an artery, and from these capillaries arise the hepatic veins which open into the inferior vena cava as that vessel grooves the under surface of the liver.

Of the other visceral veins, both renals, the right capsular, and the right spermatic or ovarian open directly into the inferior vena cava; whilst the left capsular and left spermatic or ovarian only join that vessel indirectly through the left renal.

Two of the superficial veins of the lower part of the anterior abdominal wall, the superficial epigastric and superficial circumflex iliac, enter the long saphenous vein; and two of the deep veins from the like situation, the deep epigastric and deep circumflex iliac, enter the external iliac vein. The blood in these vessels, however, can flow upwards as well as in the normally downward direction. In obstruction of the inferior vena cava they become greatly enlarged, and form, with the superior epigastric vein and with other superficial veins of the thorax with which they anastomose, one of the chief channels for the return of the blood from the lower limbs.

The veins of the pelvis, which receive the veins from the perinaeum and gluteal region, join the internal iliac vein.

THE INFERIOR VENA CAVA

The **inferior** or **ascending vena cava** (fig. 391) is the large vessel which returns the blood from the lower extremities and the abdomen and pelvis. It is formed by the confluence of the right and left common iliac veins opposite the body of the fifth lumbar vertebra, ascends in front of the lumbar vertebræ to the right of the abdominal aorta, passes through the caval opening in the diaphragm, and ends in the lower and back part of the right auricle of the heart on a level with the lower border of the ninth thoracic vertebra. At its origin it lies behind the right common iliac artery on a plane posterior to the aorta, but as it ascends it passes slightly forward and to the right, getting on a plane anterior to the aorta, and becoming separated from that artery by the right crus of the diaphragm and the lobulus Spigelii of the liver. Whilst in contact with the liver it lies in a deep groove on the hinder surface of that organ, the groove being often converted into a distinct canal by a thin portion of the hepatic substance bridging across the groove. As it passes through the diaphragm its walls are attached to the tendinous margins of the caval opening, and are thus held apart when the muscle contracts. On the thoracic side of the diaphragm it lies for about half an inch within the pericardium, the serous layer of that membrane being reflected over it.

Relations.—In front it is covered by the peritoneum, and crossed by the right spermatic artery, branches of the aortic plexus of the sympathetic, the transverse colon, the root of the mesentery, the duodenum, the head of the pancreas, the portal vein, and the liver. The median group of the lumbar lymphatic glands are also in front of it below, and at its commencement the right common iliac artery rests upon it.

Behind, it lies on the lumbar vertebræ, the right lumbar arteries, the right renal artery, the right semilunar ganglion, and the right crus of the diaphragm.

To the **right** are the peritoneum, liver, and psoas muscle.

To the **left** is the aorta, and higher up the right crus of the diaphragm.

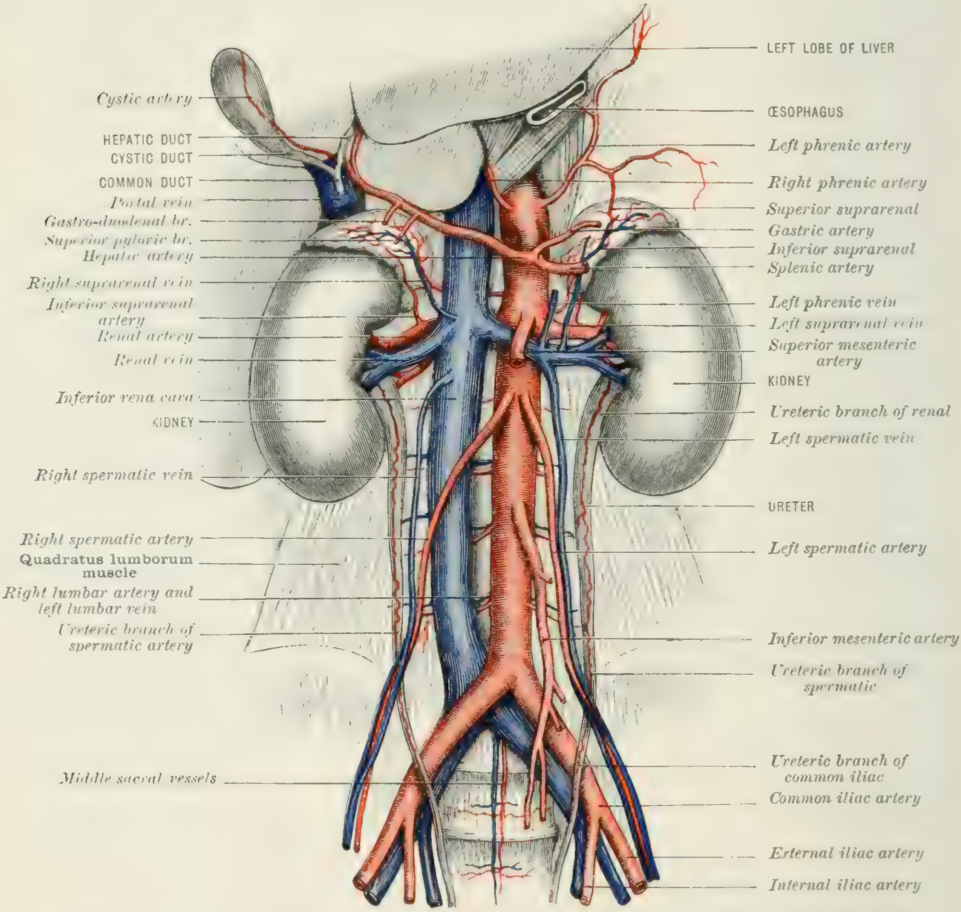
Tributaries.—The inferior vena cava receives the following veins:—(1) the renal veins; (2) the right suprarenal vein; (3) the right spermatic or (4) the right ovarian vein; (5) the lumbar veins; (6) the inferior phrenic veins; (7) the hepatic veins; and (8) the right and left common iliac veins.

(1) The **renal** or **emulgent veins** return the blood from the kidneys. They are short but thick trunks, and open into the vena cava nearly at right angles to that vessel. The vein on the left side, like the kidney, is a little higher than on the right, and is also longer, in consequence of its having to cross the aorta. The comparative shortness of the right renal vein should be borne in mind in the operation of nephrectomy, since, if too much traction is made on the pedicle, not only the vein, but a portion of the vena cava may be drawn into the ligature, as shown in a specimen in St. Bartholomew's Hospital Museum. Each vein lies in

front of its corresponding artery. The left vein crosses in front of the aorta, just below the origin of the superior mesenteric artery. It is covered by the third portion of the duodenum, and receives the left spermatic, or the left ovarian in the female, and usually the left suprarenal, and sometimes the left phrenic. There are rudiments of valves in each vein where it joins the vena cava. Those on the right side, however, are less well marked.

(2) **The suprarenal veins.**—There is usually only one suprarenal vein on each side to return the blood brought to the suprarenal body by the three suprarenal arteries. On the **right side** the vein opens into the vena cava direct above the opening of the right renal vein. On the **left side,** it opens into the left renal.

Fig. 391.—The Abdominal Aorta and Inferior Vena Cava.


Cystic artery
HEPATIC DUCT
CYSTIC DUCT
COMMON DUCT
Portal vein
Gastro-duodenal br.
Superior pyloric br.
Hepatic artery
Right suprarenal vein
Inferior suprarenal artery
Renal artery
Renal vein
Inferior vena cava
KIDNEY
Right spermatic vein
Right spermatic artery
Quadratus lumborum muscle
Right lumbar artery and left lumbar vein
Ureteric branch of spermatic artery
Middle sacral vessels
LEFT LOBE OF LIVER
ŒSOPHAGUS
Left phrenic artery
Right phrenic artery
Superior suprarenal
Gastric artery
Inferior suprarenal
Splenic artery
Left phrenic vein
Left suprarenal vein
Superior mesenteric artery
KIDNEY
Ureteric branch of renal
Left spermatic vein
URETER
Left spermatic artery
Inferior mesenteric artery
Ureteric branch of spermatic
Ureteric branch of common iliac
Common iliac artery
External iliac artery
Internal iliac artery

(3) The **spermatic veins** return the blood from the testicle. They begin by the confluence of small branches from the body of the testicle and epididymis, and as they proceed up the spermatic cord, in front of the spermatic artery and vas deferens, become dilated and plexiform, constituting the so-called **pampiniform plexus.** After passing through the external abdominal ring, the inguinal canal, and the internal abdominal ring, the plexus merges into two veins, which lie one on each side of the spermatic artery. Along with the artery the veins pass up beneath the peritoneum, and on the left side also beneath the sigmoid flexure of the colon, across the psoas muscle and ureter, to end as a single trunk, on the right side in the inferior vena cava, and on the left side in the left renal vein. There are commonly a number of imperfect valves in the spermatic plexus and a

perfect pair at the termination of each spermatic vein. On the left side, however, the terminal valve may be wanting.

(4) The **ovarian veins** begin as the pampiniform plexus near the ovary, between the layers of the broad ligament. This plexus communicates freely with the uterine plexus of veins, and with the plexus of veins which extends from the hilum of the ovary into the ovarian ligament (the **ovarian bulb**). After passing from between the layers of the broad ligament, the plexus unites to form at first two and then a single vessel, which accompanies the ovarian artery, following a similar course to the spermatic veins in the male. The right ovarian vein opens into the inferior vena cava; the left into the left renal. They usually contain imperfect valves in their plexiform part, and a perfect valve where they join the vena cava and renal vein respectively.

(5) **The lumbar veins.**—There are usually four lumbar veins on each side corresponding to the lumbar arteries. The main trunks of these veins, which lie beside the bodies of the lumbar vertebræ, are formed by the union beneath the psoas of anterior and posterior branches. The **anterior branches** collect the blood from the front and lateral walls of the abdomen. They communicate in front with the internal mammary and epigastric veins, and then run backwards between the abdominal muscles in company with the anterior branches of the lumbar arteries to their confluence with the posterior branches. The **posterior branches** collect the blood from the loins and muscles of the back, and correspond to the posterior or dorsal division of the lumbar arteries. They receive communicating branches from the dorsal spinal plexus and from the vertebral canal, and pass forwards between the transverse processes to join the anterior branches. The trunk lumbar veins are connected beneath the psoas muscle by vertical branches, which cross in front of the transverse processes. The last lumbar vein is variously joined below by a vertical branch to the common iliac, internal iliac, lateral sacral or ilio-lumbar vein, and the first lumbar vein is similarly connected above with the commencement of the vena azygos major on the right, and the vena azygos minor on the left side. The vertical vein thus formed is known as the **ascending lumbar vein**, and is regarded by some morphologists as the remains of the primitive or cardinal vein of the embryo. The trunk lumbar veins run up beneath the tendinous arches of the psoas on the sides of the bodies of the vertebræ in company with the lumbar arteries and branches of the sympathetic nerve, and end in the inferior vena cava on its posterior aspect. The left veins are longer than the right, and pass behind the aorta.

(6) The **phrenic veins**, or **inferior phrenic veins** as they are sometimes called, follow the course of the phrenic arteries: the right opens into the vena cava direct; the left into the suprarenal, the left renal, or the vena cava.

(7) The **hepatic veins**, the largest tributaries of the vena cava, return the blood from the liver. Commencing in the substance of the liver (see LIVER), they converge as they approach its posterior surface, and unite to form two or three large branches, which open into the vena cava as it lies in the groove or canal in that organ. Some smaller vessels from the lobulus Spigelii, and other parts of the liver in the neighbourhood of the caval groove, open directly into the vena cava. The hepatic veins contain no valves, but, in consequence of those from the right and left lobe of the liver opening obliquely into the vena cava, present a semilunar fold at the lower margins of their orifices.

Chief Variations in the Inferior Vena Cava

(1) The inferior vena cava, in cases of transposition of the viscera, may lie on the left side of the aorta. (2) Without transposition it may also lie to the left of the aorta, crossing to the right to gain the caval opening immediately below the diaphragm, or after receiving the left renal vein. (3) It may be double, the left cava then usually passing across the aorta into the right after receiving the left renal vein. A communication between the right and left veins in the position of the normal left common iliac vein may or may not then exist. (4) The inferior vena cava may be absent, the blood from the lower extremities passing by a large vein in the position of the ascending lumbar and azygos veins through the diaphragm to open into the superior vena cava. The hepatic veins then open directly into the right auricle through the normal caval opening in the diaphragm. (5) The inferior vena cava may receive the left spermatic vein. (6) It may receive a left accessory renal vein passing behind the aorta, and into this the usual tributaries

of the left renal vein may open. (7) It may receive several accessory renal veins; as many as seven on each side have been met with. (8) The lumbar veins may enter it on one or both sides as a common trunk.

(8) THE COMMON ILIAC VEINS

The **common iliac veins** are formed opposite the sacro-iliac synchondrosis by the confluence of the external iliac and internal iliac veins. They converge as they ascend, and unite opposite the upper border of the fifth lumbar vertebra to form the vena cava inferior a little to the right of the median line.

The **right vein**, shorter and more vertical in direction than the left, passes obliquely behind the right common iliac artery to its outer side, where it is joined by the left common iliac vein.

The **left vein** lies to the inner side of the left common iliac artery, and, after crossing in front of the promontory of the sacrum and fifth lumbar vertebra below the bifurcation of the aorta, passes beneath the right common iliac artery to join the right vein and form the inferior vena cava. The left vein may contain an imperfect valve.

Tributaries.—The ilio-lumbar veins may enter the lower part of the common iliac, or open into the internal iliac vein. The left vein receives the middle sacral veins.

(*a*) The **ilio-lumbar veins** follow the course of the ilio-lumbar artery, and end either in the common iliac or in the internal iliac vein.

(*b*) The **middle sacral veins** ascend on either side of the middle sacral artery in front of the sacrum, to open usually by a single trunk into the left common iliac vein. They communicate with the lateral sacral veins, forming the so-called presacral plexus. Below, the middle sacral veins communicate with the haemorrhoidal veins.

Chief Variations in the Common Iliac Veins

(1) Either common iliac vein may be double, or double only for a portion of its extent. (2) One may be absent,—the external and internal iliac veins joining the opposite common iliac to form the vena cava. (3) The right and left internal iliac veins may unite and open as a common trunk at the confluence of the right and left external iliac veins to form the vena cava. (4) The middle sacral trunk vein may divide, and one branch open into the right, and the other into the left common iliac vein.

THE PORTAL VEIN AND ITS TRIBUTARIES

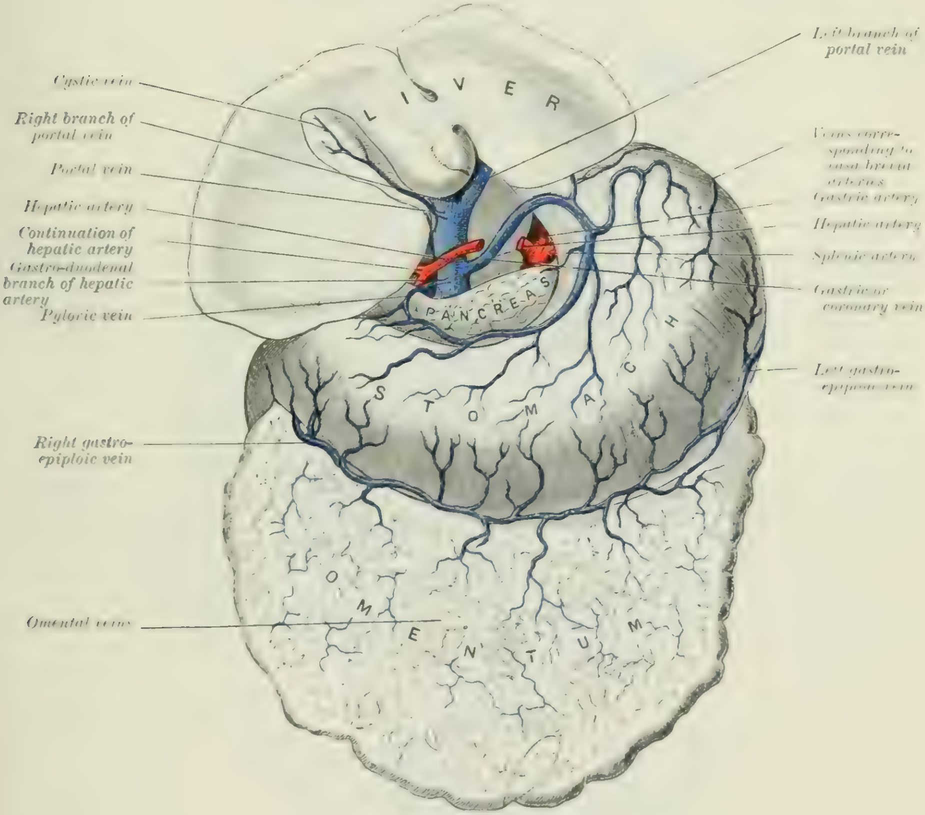
The veins corresponding to the inferior mesenteric, the superior mesenteric, and the branches of the cœliac artery, with the exception of the terminal branches of the hepatic artery, do not join the inferior vena cava direct, but unite to form a common trunk—the **portal vein.**

This vein enters the liver, and breaks up in its substance into capillaries like an artery, from which the blood is again ultimately collected by the hepatic veins, and carried by them into the inferior vena cava. The terminal branches of the hepatic artery also break up in the liver into capillaries, and from them the blood likewise finds its way finally into the hepatic veins, and thence into the inferior vena cava. Thus the arterial blood, leaving the aorta for the supply of the stomach, the intestines, the pancreas (the so-called chylopoetic viscera), and the spleen, passes, before it reaches the vena cava, through two sets of capillaries: viz. the capillaries of the viscera and the capillaries of the liver. Hence the portal system of veins may be said to terminate in capillaries at each end: to begin, like other veins, in capillaries in the viscera; but, unlike other veins, to end in capillaries like an artery, instead of in a larger and larger vein till the auricle is reached. The portal vein and its tributaries have no valves.

The **portal vein** is a thick trunk about three inches in length (7–8 cm.). It is formed behind the pancreas, opposite the right side of the body of the second lumbar vertebra, by the union of the superior mesenteric with the splenic vein. After passing behind the first part of the duodenum, and then between the layers of the lesser omentum in company with the hepatic artery and the hepatic duct, it enters the transverse or portal fissure of the liver, and there divides into a right and a left branch. In this course it passes upwards and to the right, having both the hepatic artery and the common bile duct in front, the former to the left, the latter to the right. It is surrounded by branches of the hepatic plexus of the sympathetic nerve, and by numerous lymphatic vessels and some glands. The connective tissue sheath enclosing these structures is called the capsule of Glisson. Just before it divides it is somewhat dilated, the dilated portion being called the **sinus of the portal vein.** The division into right and left branches takes place towards the right end of the transverse fissure of the liver. The **right branch** is shorter and thicker than the left, and supplies the right lobe of the liver and a branch to the quadrate lobe. The **left branch** is longer and smaller than the right, and supplies the left lobe, and gives a branch to the Spigelian and quadrate lobes. It is joined, as it crosses the longitudinal fissure, by a fibrous cord, known as the round ligament of the liver or the obliterated umbilical vein, and posteriorly by a second fibrous cord, the remains of the ductus venosus. In the fœtus the blood passes through the umbilical vein and ductus venosus directly into the vena cava, a very small quantity only turning to the right and left into the branches of the portal vein. Before birth, the blood in that part of the left branch of the portal vein which lies between the trunk of the vena porta and the umbilical vein travels from left to right; but after birth, as the portal circulation becomes freely established and the umbilical vein and ductus venosus are obliterated, in the opposite direction, i.e. from right to left.

FIG. 392.—THE VEINS OF THE STOMACH AND THE PORTAL VEIN.

(From a dissection by W. J. Walsham.)


Cystic vein
Right branch of portal vein
Portal vein
Hepatic artery
Continuation of hepatic artery
Gastro-duodenal branch of hepatic artery
Pyloric vein
Right gastro-epiploic vein
Omental veins
Left branch of portal vein
Veins corresponding to vasa brevia arteries
Gastric artery
Hepatic artery
Splenic artery
Gastric or coronary vein
Left gastro-epiploic vein
LIVER
PANCREAS
STOMACH
OMENTUM

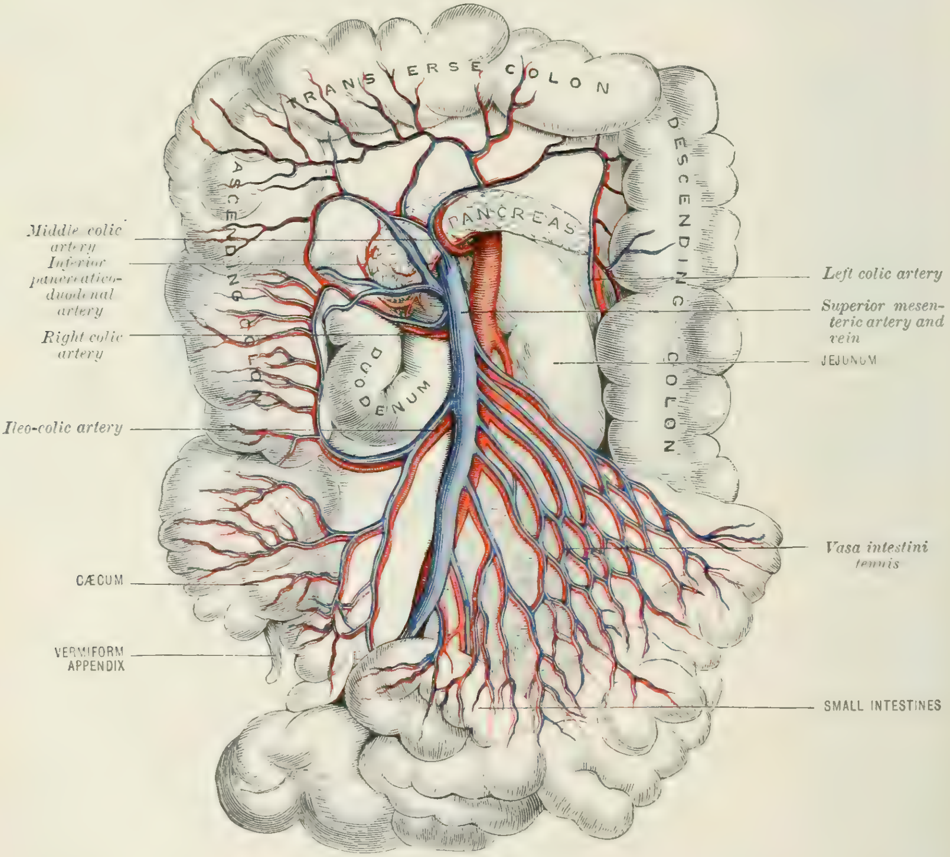
Tributaries.—The pyloric, the gastric, the cystic (which latter usually enters the right branch), the superior mesenteric, and the splenic.

The **pyloric vein** begins near the pylorus in the lesser curve of the stomach, and, running from left to right with the superior pyloric artery, opens directly into the lower part of the portal vein. It receives branches from the pancreas and duodenum.

The **gastric** or **coronary vein** runs with the gastric artery at first from right to left, along the lesser curve of the stomach, towards the cardiac end, and then, turning to the right, passes across the spine from left to right to end in the portal trunk a little higher than the pyloric vein (fig. 392). At the cardiac end of the stomach it receives small branches from the œsophagus.

FIG. 393.—THE SUPERIOR MESENTERIC VEIN.

(The colon is turned up, and the small intestines are drawn over to the left side.)


TRANSVERSE COLON
ASCENDING COLON
DESCENDING COLON
PANCREAS
DUODENUM
Middle colic artery
Inferior pancreatico-duodenal artery
Right colic artery
Ileo-colic artery
CÆCUM
VERMIFORM APPENDIX
Left colic artery
Superior mesenteric artery and vein
JEJUNUM
Vasa intestini tenuis
SMALL INTESTINES

The **cystic vein** returns the blood from the gall-bladder. It usually opens into the right branch of the portal vein.

The **superior mesenteric vein** begins in tributaries which correspond with the branches of the superior mesenteric artery. It courses upwards a little, in front and to the right of the artery, passing with that vessel from between the layers of the mesentery in front of the duodenum, and behind the pancreas, where it joins the splenic vein to form the portal trunk.

Tributaries.—In addition to the tributaries corresponding to the branches of the superior mesenteric artery—viz. the ileo-colic, right colic, middle colic, and small intestinal veins (fig. 393)—it receives the **right gastro-epiploic** and the **pancreatico-duodenal veins** just before its termination in the portal vein.

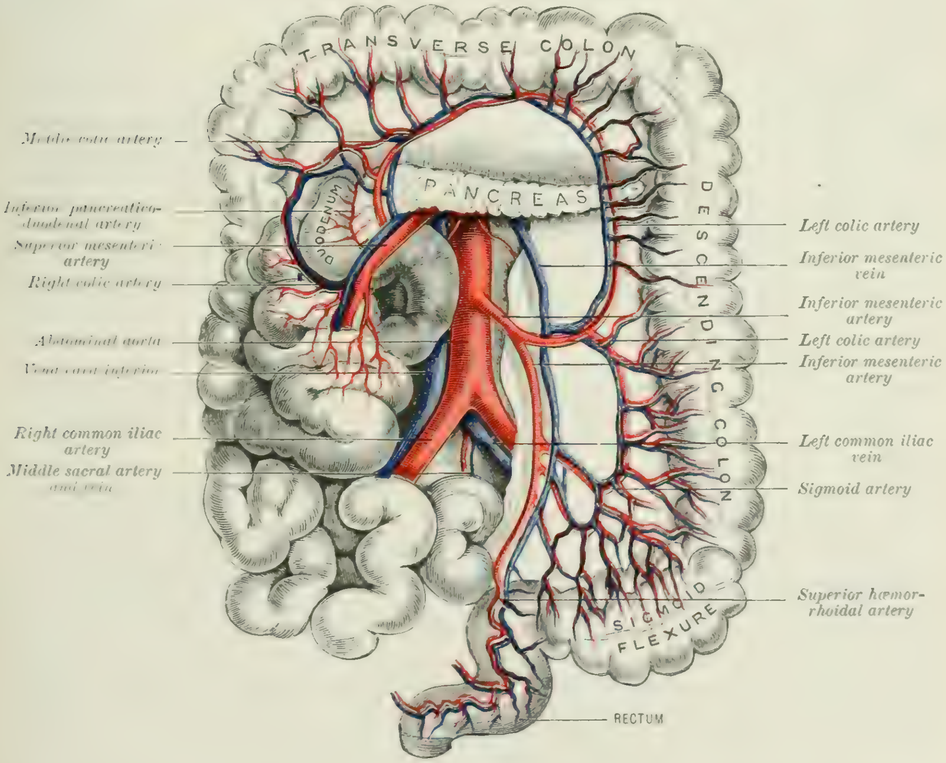
The **right gastro-epiploic vein** accompanies the artery of that name. It runs from left to right along the greater curvature of the stomach, receiving branches from the anterior and posterior surfaces of that viscus, and from the great omentum, and, passing behind the first portion of the duodenum, ends in the superior mesenteric vein just before that vessel joins the portal trunk.

The **pancreatico-duodenal vein** runs with the corresponding arteries between the head of the pancreas and the second portion of the duodenum, and ends in the superior mesenteric vein a little below the spot where that vessel is joined by the right gastro-epiploic vein.

The **splenic vein** issues as several large branches from the hilum of the spleen. These soon unite to form a large trunk, which passes across the aorta and spine in company with the splenic artery, below which it lies, to join at nearly a right angle the superior mesenteric vein. In this course it lies behind the pancreas; and at its union with the superior mesenteric to form the vena porta, in front of the inferior vena cava.

FIG. 394.—THE INFERIOR MESENTERIC VEIN.

(The colon is turned up, and the small intestines are drawn to the right side.)


TRANSVERSE COLON
Middle colic artery
PANCREAS
DUODENUM
Inferior pancreatico-duodenal artery
Superior mesenteric artery
Right colic artery
Abdominal aorta
Vena cava inferior
Right common iliac artery
Middle sacral artery and vein
DESCENDING COLON
Left colic artery
Inferior mesenteric vein
Inferior mesenteric artery
Left colic artery
Inferior mesenteric artery
Left common iliac vein
Sigmoid artery
Superior hæmorrhoidal artery
SIGMOID FLEXURE
RECTUM

Tributaries.—It receives veins corresponding to the **vasa brevia arteries** from the cardiac end of the stomach, the **left gastro-epiploic vein,** veins from the **pancreas,** and the **inferior mesenteric vein.**

The **left gastro-epiploic vein** accompanies the left gastro-epiploic artery. It runs from right to left along the greater curvature of the stomach, receives branches from the stomach and omentum, and opens into the commencement of the splenic vein.

The **inferior mesenteric vein** begins at the rectum in the superior and middle hæmorrhoidal veins. It passes out of the pelvis with the inferior mesenteric artery; but, after receiving the veins corresponding with the sigmoid and left colic branches of that vessel, it leaves the artery and runs upwards on the psoas to the left of the aorta and behind the peritoneum. On approaching the pancreas it turns slightly inwards, and passes obliquely behind that gland to join the splenic vein just before the latter unites with the superior mesenteric to form the vena porta.

THE VEINS OF THE PELVIS

The **veins of the pelvis**, with the exception of the middle sacral vein, which terminates in the left common iliac vein, open into the internal iliac vein. Under the head of pelvic veins are included all of those corresponding to the branches of the internal iliac artery except the hypogastric branch, although some of these veins do not return the blood from the pelvic walls or viscera.

The **internal iliac vein** is formed by the confluence of the veins (except the umbilical) corresponding to the branches of the internal iliac artery. It varies considerably in length, but is usually quite a short trunk, extending from the upper part of the great sacro-sciatic foramen to the sacro-iliac synchondrosis, where it joins the external iliac to form the common iliac vein. It lies behind and a little internal to the internal iliac artery. It contains no valve.

Tributaries.—The internal iliac vein receives directly or indirectly the following branches: the gluteal, ilio-lumbar, lateral sacral, obturator, sciatic, pudic, dorsal penile, prostatic, vesical, and hæmorrhoidal veins. The **single umbilical vein**—the vein corresponding to the right and left hypogastric arteries and their continuation, the umbilical arteries—does not enter the pelvis, but, leaving the umbilical arteries at the navel, passes along the falciform ligament to the liver. After birth it is converted into a fibrous cord. (See PORTAL VEIN, page 634.)

The **gluteal veins** accompany the gluteal artery, and, passing through the upper part of the great sciatic foramen, open into the internal iliac vein near its termination, either separately or as a single trunk.

The **ilio-lumbar veins** open into the internal iliac a little higher than the gluteal. At times they join the common iliac vein.

The **lateral sacral veins** join the gluteal or the internal iliac at or about the same situation as the gluteal. They form with the middle sacral veins a plexus in front of the sacrum, and receive branches from the sacral canal.

The **obturator vein,** which lies below the obturator artery as it crosses the side of the pelvis, opens into the front of the internal iliac vein a little below the gluteal. Its branches correspond to those of the artery.

The **sciatic veins** accompany the sciatic artery, and, as a rule, unite to form a single trunk before joining the internal iliac a little below the obturator vein.

All the above veins so closely follow the ramifications of their respective arteries, that no further special description of them is required. They all contain valves.

The **pudic vein** does not begin as the dorsal vein of the penis, but issues from the corpus cavernosum with the artery of that body. It communicates, however, with the dorsal vein before the latter pierces the triangular ligament. In the rest of its course it runs with the pudic artery, receiving tributaries corresponding to the branches of that vessel. It terminates in the lower part of the internal iliac vein.

The **dorsal vein of the penis** begins in a plexus around the corona glandis, then runs along the centre of the dorsum of the penis between the two pudic arteries. In this course it receives large tributaries from the interior of the organ, which, emerging for the most part between the corpus spongiosum and corpus cavernosum, wind obliquely over the outer surface of the latter structure to the dorsum of the penis to end in the dorsal vein. At the root of the penis the dorsal vein leaves the dorsal arteries, and, passing straight backwards between the two layers of the suspensory ligament, and then through either the subpubic ligament or the upper part of the triangular ligament of the pelvis (fig. 371) bifurcates, each branch passing backwards and downwards to the prostatico-vesical plexus of veins. At times the dorsal vein begins as two branches, which run between the dorsal arteries and only unite to form a single trunk about an inch and a half from the triangular ligament. Before passing through the triangular ligament, it communicates on each side with the primary radicals of the pudic vein. After dividing into a right and a left branch within the pelvis, each vessel generally communicates with the obturator vein by a branch passing over the back of the pubes to the obturator foramen.

The **prostatico-vesical plexus** surrounds the prostate and the neck and lower fundus of the bladder. It receives in front the right and left divisions of the dorsal vein of the penis, and communicates posteriorly with the hæmorrhoidal plexus. The prostatic veins and the vesical plexus open into it. The veins forming the plexus are of large size, especially in old men, in whom they often become varicose, and contain phlebolitis, or vein-stones. The plexus is surrounded by a kind of capsule formed by the recto-vesical process of the pelvic fascia. It terminates in a single stem on each side which opens into the internal iliac vein.

The **vesical plexus** surrounds the upper fundus, the sides, and the anterior and posterior surfaces of the bladder. It is situated between the muscular coat and the peritoneum, and where the bladder is uncovered by peritoneum external to the muscular coat in the pelvic cellular tissue. It opens into the prostatico-vesical plexus.

The **hæmorrhoidal plexus of veins** surrounds the rectum, and is situated at the lower part of that tube between the muscular and mucous coats. The veins of this plexus terminate in the inferior, middle, and superior hæmorrhoidal veins. The **inferior** join the pudic; the **middle** accompany the middle hæmorrhoidal arteries, and open into the internal iliac and superior hæmorrhoidal veins; the **superior** form the commencement of the inferior mesenteric vein, and through this the blood gains the portal vein. None of these veins have any valves, hence the enlargement of the inferior hæmorrhoidal veins, a condition known as piles, when the portal vein is obstructed, as from compression of its capillaries in cirrhosis of the liver. Through the hæmorrhoidal veins a free communication is established between the systemic and portal system of veins.

5. THE VEINS OF THE UPPER EXTREMITY

The **veins of the upper limb** consist of two sets—a **superficial** and a **deep.** The superficial veins ramify in the subcutaneous tissue above the deep fascia; the deep accompany the arteries, and have practically the same relations as those vessels. The superficial and deep veins communicate at frequent intervals through the intermuscular veins which run between the muscles and perforate the deep fascia. Both sets of veins are provided with valves, but the valves are more numerous in the deep than in the superficial. There is usually a valve where the deep veins join the superficial. The superficial veins are larger than the deep, and take the greater share in returning the blood.

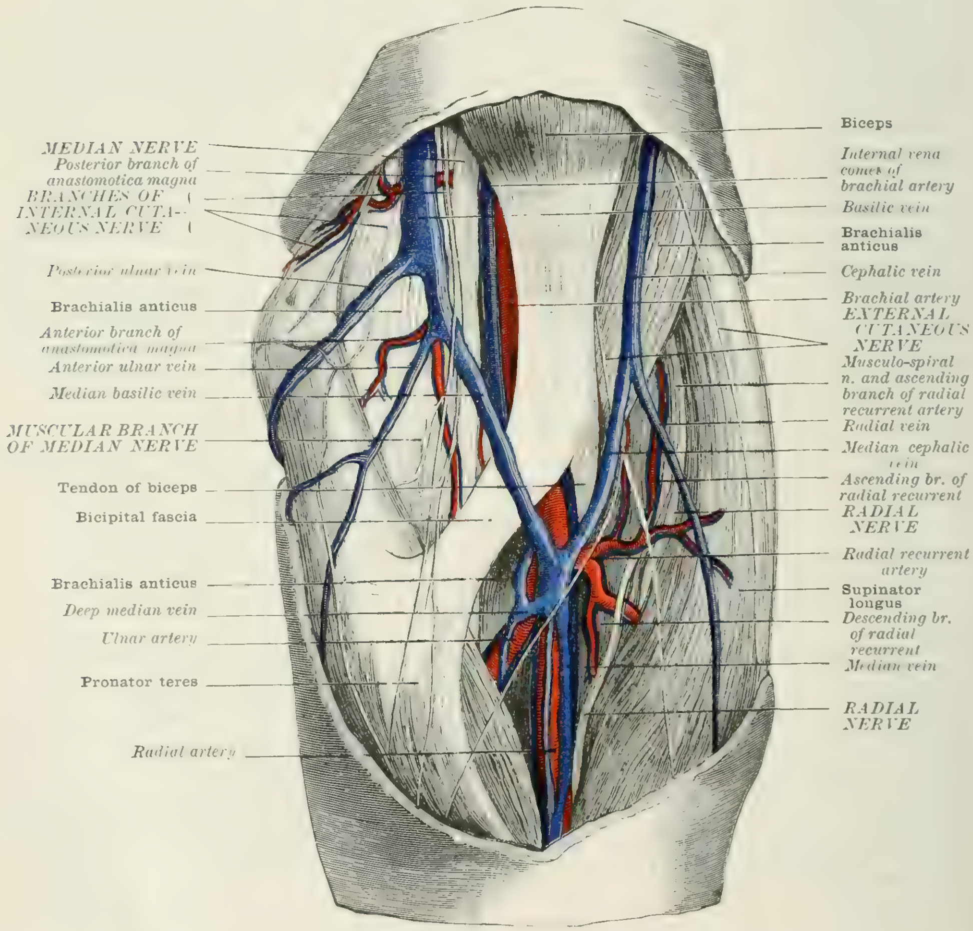
I. THE SUPERFICIAL VEINS OF THE UPPER EXTREMITY

The **superficial veins** begin in two irregular venous plexuses: one situated on the back of the hand, and the other on the front of the wrist. From the radial side of the dorsal plexus, a single vein, the **superficial radial,** runs up the forearm as far as the elbow. From the ulnar side of the plexus, two veins course up the inner side of the forearm—the **anterior** and **posterior superficial ulnar veins**—and, joining together a little below the bend of the elbow, form a **single superficial ulnar vein.** From the anterior plexus a vein runs up the middle of the front of the forearm—the **superficial median vein**—and, after receiving a branch from the deep veins at the bend of the elbow (the **deep median**), divides into an outer branch (the median cephalic) and an inner branch (the median basilic). The **median cephalic** runs upwards and outwards to join the superficial radial vein. The united trunk, then known as the **cephalic,** continues up the outer side of the arm, and opens into the axillary vein. The **median basilic** runs upwards and inwards to join the superficial ulnar vein. The trunk thus formed (the **basilic**) courses up the inner side of the arm to join the inner brachial vena comes and form the **axillary vein.**

The **dorsal venous plexus,** which is situated on the back of the hand, sometimes takes the form of an irregular arch, stretching across from the radial to the ulnar side; at other times, the form of two more or less distinct plexuses, a radial dorsal and an ulnar dorsal; but an exactly similar arrangement is seldom met with in any two consecutive bodies.

FIG. 395.—THE BEND OF THE ELBOW WITH THE SUPERFICIAL VEINS, LEFT SIDE.

(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)


MEDIAN NERVE
Posterior branch of anastomotica magna
BRANCHES OF INTERNAL CUTANEOUS NERVE
Posterior ulnar vein
Brachialis anticus
Anterior branch of anastomotica magna
Anterior ulnar vein
Median basilic vein
MUSCULAR BRANCH OF MEDIAN NERVE
Tendon of biceps
Bicipital fascia
Brachialis anticus
Deep median vein
Ulnar artery
Pronator teres
Radial artery
Biceps
Internal vena comes of brachial artery
Basilic vein
Brachialis anticus
Cephalic vein
Brachial artery
EXTERNAL CUTANEOUS NERVE
Musculo-spiral n. and ascending branch of radial recurrent artery
Radial vein
Median cephalic vein
Ascending br. of radial recurrent
RADIAL NERVE
Radial recurrent artery
Supinator longus
Descending br. of radial recurrent
Median vein
RADIAL NERVE

The distal part of the arch or plexus receives the digital veins from the fingers. These **digital veins,** two to each finger, start from a minute plexus about the nail, run along the finger, one on either side, to the cleft, where each unites with the vein from the contiguous side of the neighbouring finger, and so form single trunks which proceed upwards to the arch. The veins of the fingers communicate at frequent intervals by cross branches above and below the interphalangeal joints.

Here it may be noted, that whilst the veins which return the chief part of the blood from the fingers are superficial and dorsally placed, the arteries are deep and situated towards the palmar surface. Minute venae comites, however, lie on each side of the digital arteries.

The **anterior median plexus** is situated on the fore part of the wrist. It is very irregular in its arrangement, and receives a few small branches from the palm and from the outer and front part of the thumb.

The **superficial radial vein** begins at the radial end of the dorsal venous plexus or arch, and, after receiving veins from the thumb and communicating with the deep veins accompanying the radial artery, courses up the radial side of the forearm along with the musculo-cutaneous nerve. It receives numerous branches from the front and outer surface of the forearm, and a little above the bend of the elbow, in the slight sulcus at the outer side of the bicipital prominence, unites with the median cephalic vein to form the cephalic vein (figs. 395, 396). It contains from four to six valves.

The **anterior superficial ulnar vein** begins on the inner and front surface of the wrist, runs up the inner side of the forearm, and joins the posterior ulnar vein just below the bend of the elbow; or it may unite directly with the median basilic to form the basilic vein. In the latter case the posterior superficial ulnar vein joins the basilic (fig. 395). The anterior ulnar vein is accompanied by the anterior branch of the internal cutaneous nerve. It contains about four valves.

The **posterior superficial ulnar vein,** larger than the anterior, begins at the ulnar side of the dorsal plexus. It receives the **vena salvatella,** or vein of the little finger, and communicates with the deep ulnar veins by means of an intermuscular branch which passes beneath the abductor minimi digiti. As it courses upwards on the posterior aspect of the forearm it receives numerous cutaneous branches, and near the bend of the elbow joins the anterior superficial ulnar vein. Just below the internal condyle the united trunk turns forwards to unite with the median basilic to form the basilic vein. When the basilic is formed by the union of the anterior ulnar and median basilic (fig. 395), the posterior ulnar vein may end in the basilic vein direct. It contains about four valves.

The **superficial median vein** begins in the anterior plexus in front of the wrist, and passes up the centre of the front of the forearm, receiving numerous cutaneous branches, and communicating on each side with the superficial ulnar and radial veins. At the bend of the elbow it receives the **deep median vein,** which is formed by the union of the outer vena comes of the ulnar artery with the muscular and radial recurrent veins. The short trunk pierces the deep fascia to join the median vein, which immediately afterwards bifurcates into the median basilic and median cephalic.

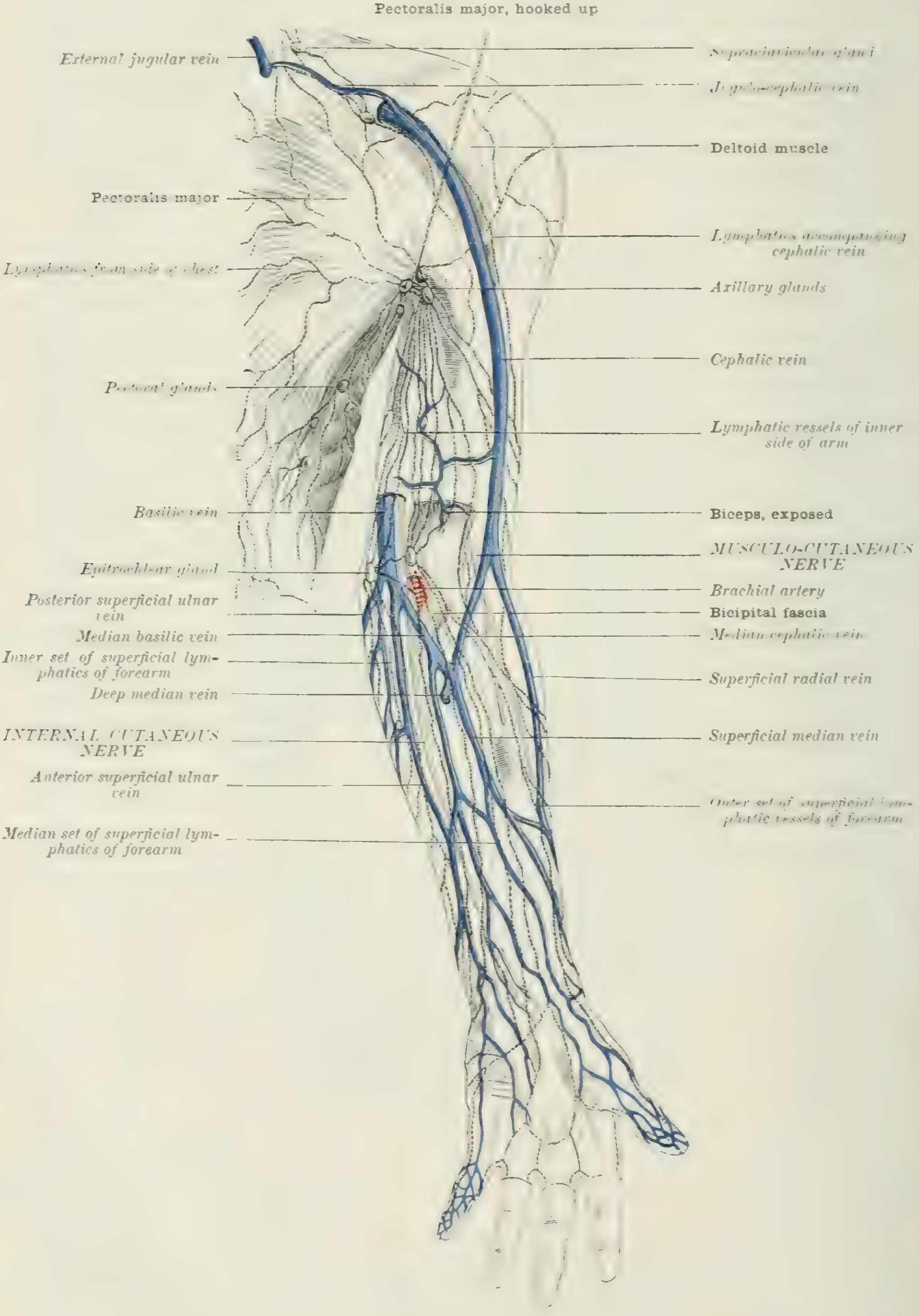
The **median cephalic vein,** the smaller branch of the median, runs upwards and outwards in the sulcus between the biceps and supinatus longus, and, joining the superficial radial vein immediately above the bend of the elbow, forms the cephalic vein. The musculo-cutaneous nerve passes beneath it, a few fibres of the nerve lying superficial to it.

The **median basilic vein,** the larger of the two divisions of the median vein, runs upwards and inwards across the semilunar fascia of the biceps, by which it is separated from the brachial artery, to the internal bicipital sulcus, where it joins one of the superficial ulnar veins or their united trunk to form the basilic. Fibres of the internal cutaneous nerve pass both in front and behind it. This vein is especially prominent at the bend of the elbow; and, on account of its larger size and superficial position, was usually chosen in venesection when this operation was in vogue. The lancet, if care was not taken, was liable to pass through the bicipital fascia and injure the artery, when varicose aneurysm or aneurysmal varix was a common result.

The **cephalic vein,** formed by the union of the median cephalic with the superficial radial vein, courses upwards first in the external bicipital sulcus, and then in the interval between the pectoralis major and the deltoid, perforates the costo-coracoid membrane, and, crossing the first part of the axillary artery, opens into the axillary vein. It contains a pair of valves where it joins the axillary vein.

The **basilic vein**—formed by the union of the median basilic and one of the superficial ulnar veins or their united trunk—passes up the inner side of the arm a little internal to the biceps, and nearly over the course of the brachial artery. At the junction of the middle with the lower third of the arm it pierces the deep fascia, and ends by uniting with the inner brachial vena comes to form the axillary vein.

Fig. 396.—Superficial Veins and Lymphatics of the Left Forearm and Arm. (Walsham.)


Pectoralis major, hooked up
External jugular vein
Supraclavicular gland
Jugulo-cephalic vein
Deltoid muscle
Pectoralis major
Lymphatics accompanying cephalic vein
Lymphatics from side of chest
Axillary glands
Cephalic vein
Pectoral glands
Lymphatic vessels of inner side of arm
Basilic vein
Biceps, exposed
MUSCULO-CUTANEOUS NERVE
Epitrochlear gland
Brachial artery
Posterior superficial ulnar vein
Bicipital fascia
Median basilic vein
Median cephalic vein
Inner set of superficial lymphatics of forearm
Superficial radial vein
Deep median vein
INTERNAL CUTANEOUS NERVE
Superficial median vein
Anterior superficial ulnar vein
Outer set of superficial lymphatic vessels of forearm
Median set of superficial lymphatics of forearm

II. *THE DEEP VEINS OF THE UPPER EXTREMITY*

The **deep veins of the upper extremity** accompany their corresponding arteries and consequently require no detailed description. There are two veins to each artery below the level of the axilla, known as the companion veins or venæ comites. In the leg, as will be afterwards noticed, the venæ comites of the main arteries extend as far as the knee only. The deep veins all contain numerous valves, and communicate at frequent intervals through intermuscular veins with the superficial.

Beginning at the fingers, two minute veins accompany each digital artery along the sides of the fingers, and, uniting at the cleft, form interdigital veins which join the venæ comites of the arteries, forming the superficial palmar arch. In like manner the veins accompanying the arteries forming the deep arch receive tributaries corresponding to the branches of that arch. The venæ comites from the ulnar side of the superficial and deep arches unite at the spot where the ulnar artery divides into the superficial and deep branch to form two ulnar venæ comites; whilst those on the radial side of the superficial and deep arch accompany the superficial volar artery and the termination of the radial artery respectively, and unite at the spot where the superficial volar is given off from the radial artery, to form the radial venæ comites. The ulnar and radial venæ comites thus formed course up the forearm with their respective arteries, receiving numerous tributaries from the muscles amongst which they run, and giving frequent communications to the superficial veins. They finally unite at the bend of the elbow to form the brachial venæ comites. The ulnar venæ comites receive, before joining the radial, the companion veins of the interosseous arteries. At the bend of the elbow the deep veins are connected with the superficial median vein by a short, thick trunk, the **deep median vein.**

The **brachial venæ comites** accompany the brachial artery, the inner vein receiving at the lower border of either the teres major or subscapularis muscle the outer vein and the basilic vein, to form a single axillary vein.

The venæ comites of the arteries of the arm anastomose with one another by frequent cross branches.

The **axillary vein** is formed by the junction of the inner brachial vena comes with the basilic vein at the lower border of either the teres major or subscapularis muscle. It is a vessel of large size, conveying as it does nearly the whole of the returned blood from the upper extremity. It accompanies the axillary artery through the axilla, lying to its inner side and at the upper part of the space on a slightly lower plane. At the outer border of the first rib it changes its name to the subclavian. It has one or two axillary glands in close connection with it, and is liable, if care is not taken, to be wounded in removing these glands when infiltrated with cancer secondary to cancer of the breast. The vein contains a pair of valves, usually placed near the lower border of the subscapularis muscle. It receives in its course through the axilla:—(1) The subscapular veins which accompany the subscapular artery; (2) the circumflex veins accompanying the circumflex arteries; (3) the long thoracic veins accompanying the long thoracic artery; (4) numerous small veins returning the blood from the axillary glands; (5) the veins corresponding to the branches of the thoracic axis; and (6) the cephalic vein.

The **subclavian vein** (fig. 329) is the continuation of the axillary. It begins at the outer border of the first rib, and terminates by joining the internal jugular to form the innominate vein opposite the outer part of the sterno-clavicular articulation. It lies anterior to the subclavian artery and on a lower plane, and is separated from the artery in the second part of its course by the scalenus anticus muscle. The subclavian vein, just before the spot where it is joined by the external jugular, contains a pair of valves.

Tributaries.—Near the outer border of the sterno-mastoid muscle it receives the external jugular vein. Occasionally the cephalic vein, or a branch from the cephalic (the jugulo-cephalic), passes over the clavicle to the subclavian (fig. 396).

Chief variations.—(1) The subclavian vein may run on a higher plane than usual, lying even above the artery. (2) It may pass with the artery behind the scalenus anticus. (3) It may run behind the scalenus anticus and the artery in front of that muscle. (4) It may split and enclose the scalenus anticus. (5) It may pass between the clavicle and the subclavius. (6) It may receive directly the transverse cervical, the suprascapular, the anterior jugular, or the cephalic vein, or the venæ comites of the brachial artery.

6. *THE VEINS OF THE LOWER EXTREMITY*

The **veins of the lower extremity** are divided into the superficial and the deep. The **superficial veins** lie in the subcutaneous tissue superficial to the deep fascia, through which they receive numerous communicating branches from the deep veins. They are collected chiefly into two main trunks, which, beginning on the foot, extend upwards, one lying antero-internally, and the other postero-externally. The former finally joins the femoral vein by passing through the deep fascia at the groin; the latter the popliteal by perforating the fascia at the ham. The **deep veins,** on the other hand, accompany their corresponding arteries. Below the knee there are two veins to each artery; above it, excepting at the back of the thigh, there is only one vein to each artery. All the veins of the lower limb have valves which are more numerous than in the veins of the upper extremity, and in the deep than in the superficial veins.

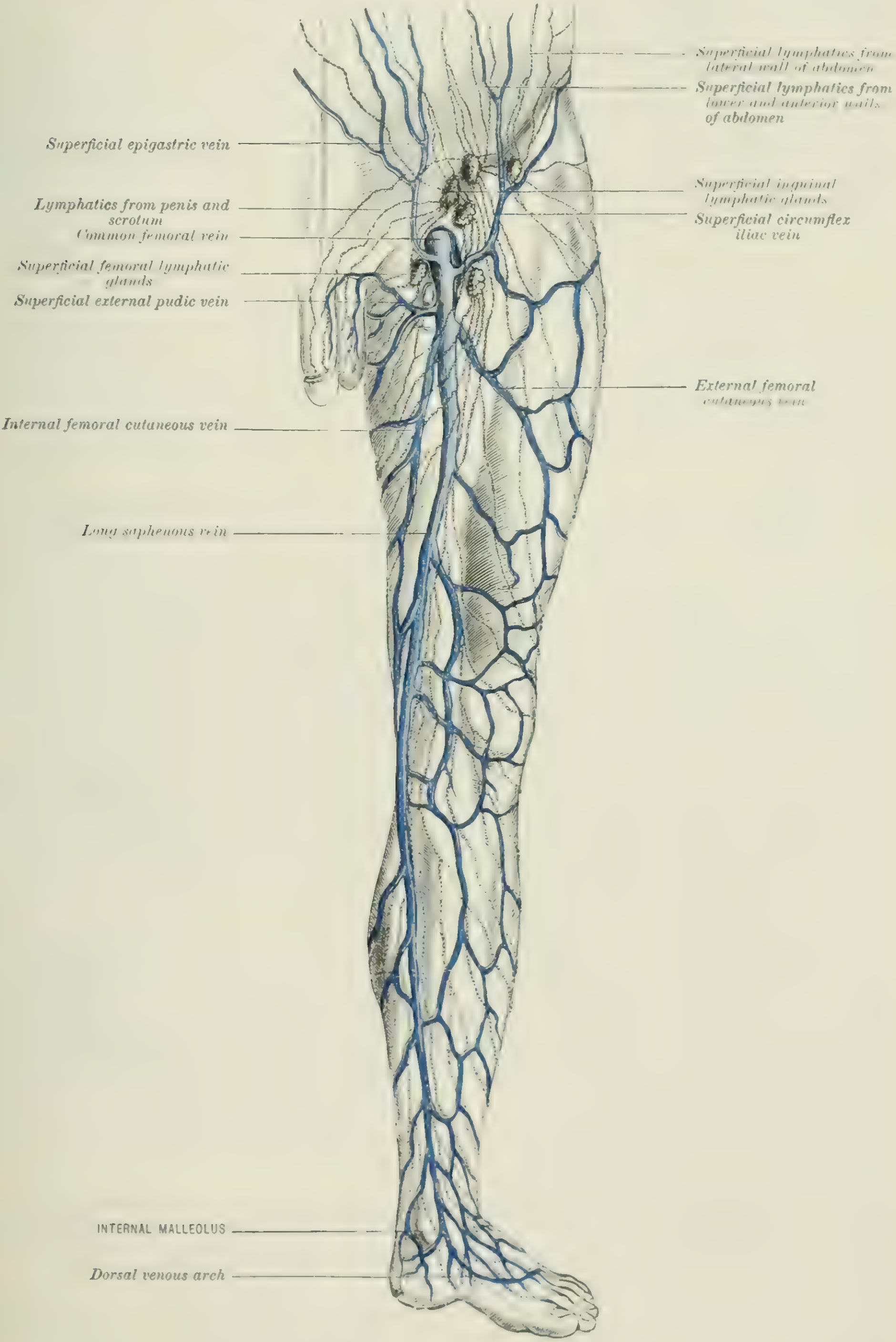
I. *THE SUPERFICIAL VEINS OF THE LOWER EXTREMITY*

The **superficial veins of the lower limb** are collected into two main trunks. One, the long or internal saphenous, which is placed antero-internally; the other, the short or external saphenous, which is placed postero-externally. These veins commence on the dorsum of the foot in an irregular arch, which stretches across the instep with its convexity towards the toes. The arch receives branches from the four outer toes and dorsum of the foot, and one branch of somewhat larger size than the rest from the inner side of the great toe. It also communicates with the venæ comites accompanying the dorsal artery of the foot (fig. 397).

The **long** or **internal saphenous vein** commences on the inner side of the foot at the inner end of the above described venous arch, and, after receiving branches from the sole which join it by turning over the inner border of the foot, passes upwards in front of the inner ankle, and then obliquely upwards and backwards about a finger's breadth from the posterior border of the tibia in company with the internal saphenous nerve, which becomes superficial just below the knee. Continuing its course upwards, it passes behind the internal condyle, and then runs upwards and somewhat outwards on the inner side of the front of the thigh to about an inch and a half below Poupart's ligament, where, after receiving the superficial circumflex iliac, superficial epigastric, and superficial external pudic veins, it dips through the saphenous opening in the fascia lata, and ends in the femoral vein. In its course up the leg and thigh it receives numerous unnamed cutaneous branches, and at variable intervals communicates with the deep veins. Just before it passes through the saphenous opening, it often receives a large vein (**external femoral cutaneous**) formed by the union of several of the cutaneous veins on the upper and outer part of the thigh, and a second vein (the **internal femoral cutaneous**) formed by the union of the cutaneous veins from the inner and back part of the thigh. The long saphenous vein contains from ten to twenty valves.

The **short** or **external saphenous vein** begins at the outer end of the venous arch, or plexus, on the dorsum of the foot. After receiving branches from the sole, which turn over the outer border of the foot, it passes behind the outer ankle, and then upwards and inwards, lying at first along the outer side of the tendo Achillis,

FIG. 397.—THE SUPERFICIAL VEINS AND LYMPHATICS OF THE LEFT LOWER LIMB. (Walsham.)


Superficial lymphatics from lateral wall of abdomen
Superficial lymphatics from lower and anterior walls of abdomen
Superficial epigastric vein
Superficial inguinal lymphatic glands
Lymphatics from penis and scrotum
Superficial circumflex iliac vein
Common femoral vein
Superficial femoral lymphatic glands
Superficial external pudic vein
External femoral cutaneous vein
Internal femoral cutaneous vein
Long saphenous vein
INTERNAL MALLEOLUS
Dorsal venous arch

afterwards along the back of the calf, in company with the external or short saphenous nerve, to about the lower part of the centre of the popliteal space, where it perforates the deep fascia, and, sinking between the two heads of the gastrocnemius, opens into the popliteal vein. As it passes up the calf between the superficial and deep fascia, it receives numerous cutaneous veins from the heel, and the outer side and back part of the leg, and communicates at intervals, through transverse or intermuscular branches, with the deep veins (venæ comites) accompanying the peroneal artery. Just before perforating the deep fascia, it receives a large descending branch from the lower and back part of the thigh, and sends upwards and inwards a communicating vein to the long saphenous. A small offshoot from the inferior sural branch of the popliteal artery accompanies the vein for a short distance down the back of the calf. The short saphenous vein contains from nine to twelve valves.

II. *THE DEEP VEINS OF THE LOWER EXTREMITY*

The **deep veins of the lower extremity** accompany the arteries, and have received corresponding names. From the foot to the knee there are two veins to each artery. These veins run on either side of the corresponding artery, and communicate at frequent intervals with each other across it. They are known as the venæ comites. From the knee upwards there is a single vein to each artery, except at the back of the thigh and in the gluteal region, where there are commonly two.

The veins of the foot and leg.—The venæ comites of the internal and external plantar arteries, after receiving small veins corresponding to the branches of these vessels, unite beneath the abductor hallucis muscle to form the venæ comites of the posterior tibial artery. These, again, receive, at the spot where the peroneal artery is given off from the posterior tibial, the venæ comites of the peroneal artery, which are formed in like manner by the confluence of the various veins corresponding to the branches of that vessel. Opposite the lower border of the popliteus muscle, the posterior tibial veins unite with the anterior tibial veins, which pass through the upper part of the interosseous membrane with the anterior tibial artery, to form the popliteal. The anterior tibial veins are the continuation of the venæ comites of the dorsal artery of the foot, which, in their turn, are formed by the confluence of the veins accompanying its various branches. The anterior tibial venæ comites thus formed run with the anterior tibial artery up the front of the leg, and, after passing through the interosseous membrane along with the artery, join the posterior tibial veins to form a single popliteal.

All these veins contain numerous valves, and communicate, by means of intermuscular branches, with the superficial veins.

The **popliteal vein** is formed by the confluence of the venæ comites of the anterior and posterior tibial arteries at the lower border of the popliteus, and extends upwards to the opening in the adductor magnus at the junction of the middle and lower third of the thigh, where it changes its name to femoral. It accompanies the popliteal artery, lying superficial to it in the whole of its course, and tightly bound down to it by its fascial sheath. At the lower part of the space it is a little internal to the artery, but, crossing the vessel obliquely as it ascends, lies a little external to it at the upper part of the space. The internal popliteal nerve lies superficial to the vein, being external to it above, then on it, and then a little to its inner side. The popliteal vein contains two or three valves.

The **chief variations of the popliteal** are:—(1) It may lie between the artery and the bone. (2) It may be double through a part or the whole of the popliteal space. (3) Two veins by frequently uniting in front and behind the artery may form a kind of plexus around the vessel. (4) It may be shorter than usual in consequence of a high union of the tibial venæ comites.

The **femoral vein**, the continuation of the popliteal upwards, extends from the tendinous opening in the adductor magnus to an inch and a half below Poupart's ligament where it joins the profunda vein to form the common femoral vein. In this course its relations are similar to those of the superficial femoral artery. As the vein passes through Hunter's canal, it lies behind and a little external to the artery. At the apex of Scarpa's triangle it is still posterior to the artery, but gradually passes to the inner side as it ascends through that space. It contains three pairs of valves. The close connection of the vein to the artery should be remembered in the operation of ligature. The sheath should be opened on its inner side, that is, well over the artery, and the point of the aneurysm needle kept closely applied to the artery lest it perforate the overlapping vein.

Tributaries.—(1) The venæ comites of the anastomotica magna artery; (2) the venæ comites corresponding to the muscular branches of the femoral.

The **profunda** or **deep femoral vein** accompanies the profunda or deep femoral artery, and receives the venæ comites corresponding to its various branches. Unlike the other veins of the lower extremity, it lies in front of its companion artery, and is at first a little internal to it. It terminates by joining the superficial femoral vein about an inch and a half below Poupart's ligament in the angle between the femoral and profunda arteries. It contains five valves.

The **common femoral vein** is a short thick trunk corresponding to the common femoral artery. It is formed by the confluence of the superficial femoral and profunda veins about an inch and a half below Poupart's ligament, and is continued upwards to the lower border of that structure, where it takes the name of external iliac. It lies on the same plane as the common femoral artery, but internal to that vessel, from which it is separated by a delicate prolongation of fascia stretching between the front and back layers of the femoral sheath. **Internally,** it is separated by a similar septum of fascia from the crural canal. It usually contains two valves: one just above the junction with the profunda vein, the other just below Poupart's ligament (fig. 372).

Tributary.—The long saphenous vein which reaches it by passing through the saphenous opening in the deep fascia.

Chief variations.—(1) The femoral vein may be double in part or in the whole of its length. (2) It may split into two and embrace the femoral artery. (3) It may pass through the adductor magnus above the femoral artery and run separate from the artery until it joins the profunda vein to form the common femoral vein. (4) It may run with the sciatic nerve and pierce the adductor magnus at the level of the lesser trochanter. When this occurs the femoral artery is usually very small, and the sciatic artery is the chief nutrient vessel of the thigh.

The **external iliac vein** is the continuation upwards of the common femoral. Beginning at the lower border of Poupart's ligament it accompanies the external iliac artery upwards and inwards along the brim of the pelvis, lying at first on the horizontal ramus of the pubes, and then on the psoas muscle. It terminates in the common iliac vein by joining the internal iliac vein behind the internal iliac artery opposite the lower border of the sacro-iliac synchondrosis. It lies at first internal to the external iliac artery, and on the left side remains internal to the artery throughout its course. On the right side, however, as it ascends, it gradually gets a little behind the artery. It contains one or two valves.

Tributaries.—(1) The **deep epigastric vein,** formed by the union of the venæ comites of the deep epigastric artery, joins the external iliac just above Poupart's ligament. (2) The **deep circumflex iliac vein,** which is formed in the same way by the confluence of the venæ comites of the deep circumflex iliac artery, joins the external iliac vein a little higher.

THE LYMPHATICS

THE **lymphatics** consist of lymphatic vessels and lymphatic glands. The lymphatic vessels carry lymph, and the lymphatics of the intestine chyle as well whilst digestion is going on. The chyle-carrying lymphatics are generally known as **lacteals.** The lymphatic glands are situated at certain spots in the course of the lymphatic vessels. The lymphatic vessels ultimately terminate either in the left or right lymphatic duct. The former, some eighteen inches in length, known as the **thoracic duct,** begins at the confluence of certain lymphatics in the abdomen, passes through the thorax, and terminates in the left innominate vein at the confluence of the left internal jugular and subclavian veins. It receives the lymphatics of both lower extremities, the lymphatics of the abdomen, except those from the convex surface of the liver, the lymphatics from the left half of the thorax, the left half of the head and neck, and the left upper extremity. The **right** lymphatic duct is a short vessel a little less than an inch in length. It receives the lymphatics from the convex surface of the liver, the right half of the thorax, the right side of the head and neck, and the right upper extremity. It ends in the right innominate vein at the confluence of the right internal jugular and subclavian veins.

The thoracic duct, or left lymphatic duct, is described with the LYMPHATICS OF THE THORAX; the right lymphatic duct with the LYMPHATICS OF THE HEAD AND NECK.

THE LYMPHATICS OF THE HEAD AND NECK

The **lymphatics of the head and neck** are divided into the **superficial** and the **deep.** The **superficial** roughly follow the course of the superficial veins. Streaming down the scalp and face, they enter the neck through corresponding groups of superficial glands, and then converge to join the superficial cervical chain and in part the deep cervical chain of glands which are situated along the course of the external and internal jugular veins respectively. The **deep** lymphatics of the head and neck follow roughly the course of the deep arteries. They include the lymphatics from the interior of the cranium; from the orbit; from the interior of the nose and mouth; from the tongue; from the pharynx, larynx, and upper part of the trachea and œsophagus, and from the thyroid gland. After passing through certain glands in their course, they terminate chiefly in the deep cervical chain of glands. The deep cervical chain of glands, after receiving the lymphatics from the superficial chain, ends in the thoracic duct on the left side, and in the **right lymphatic duct on the right side.**

I. *THE SUPERFICIAL LYMPHATIC VESSELS AND GLANDS OF THE HEAD AND NECK*

A. The Superficial Lymphatic Vessels

The **superficial lymphatic vessels** may be subdivided into the superficial lymphatics of the scalp, the face, and the neck (fig. 398).

1. The **superficial lymphatic vessels of the scalp** follow roughly the course of the superficial veins. Thus there is (1) a posterior or occipital set, which course downwards over the occipital bone to the occipital, or suboccipital glands as they are sometimes called; (2) a postero-lateral or posterior auricular set, which course downwards behind the ear, and end in the posterior auricular or sterno-mastoid glands; (3) an antero-lateral or temporal set, which accompany the superficial temporal vein in front of the ear, and end in the parotid lymphatic glands; and (4) an anterior or frontal set, which course downwards over the frontal bone and end in the facial lymphatics.

2. The **superficial lymphatic vessels of the face**—continuous at the root of the nose with the frontal set of lymphatics descending from the scalp—course downwards and backwards with the facial vein, receiving tributaries from the inner half of the eyelids, the side of the nose, the contiguous portions of the cheek, and the upper and lower lips. They end in the submaxillary lymphatic glands beneath the lower jaw. The lymphatics from the outer part of the eyelids and the outer part of the cheek run backwards and slightly downwards to the parotid lymphatic glands.

3. The **superficial lymphatic vessels of the neck** form a plexus in the subcutaneous tissues of the neck. They communicate with the superficial lymphatics of the scalp and face, and with some of the superficial lymphatics of the upper part of the thorax. They end in the superficial cervical chain of lymphatic glands.

B. The Superficial Lymphatic Glands

The **superficial lymphatic glands of the head and neck** may be divided into two sets, a transverse and a vertical (fig. 398).

1. The **transverse** occur in groups in the course of a line drawn from the occiput to the mastoid process, and thence along the zygoma and beneath the body of the lower jaw to the symphysis. They receive as afferent vessels the lymphatics of the scalp and face. Their efferent vessels pass into the superficial and deep cervical chains.

They are named:—(1) The occipital, or suboccipital; (2) the posterior auricular, or sterno-mastoid; (3) the parotid; (4) the buccal; and (5) the submaxillary.

(1) The **occipital** or **suboccipital glands** are situated at the back of the head, beneath the skin, just below the superior curved line of the occipital bone and over the insertion of the complexus muscle. They receive the lymphatic vessels from the back of the head. Their efferent vessels discharge into the superficial lymphatic glands of the neck. It is these glands which perhaps more especially are found enlarged in secondary syphilis.

(2) The **posterior auricular** or **sterno-mastoid glands**, situated over the insertion of the sterno-mastoid muscle behind the ear, receive the posterior auricular lymphatics. Their efferent vessels discharge into the superficial cervical lymphatics.

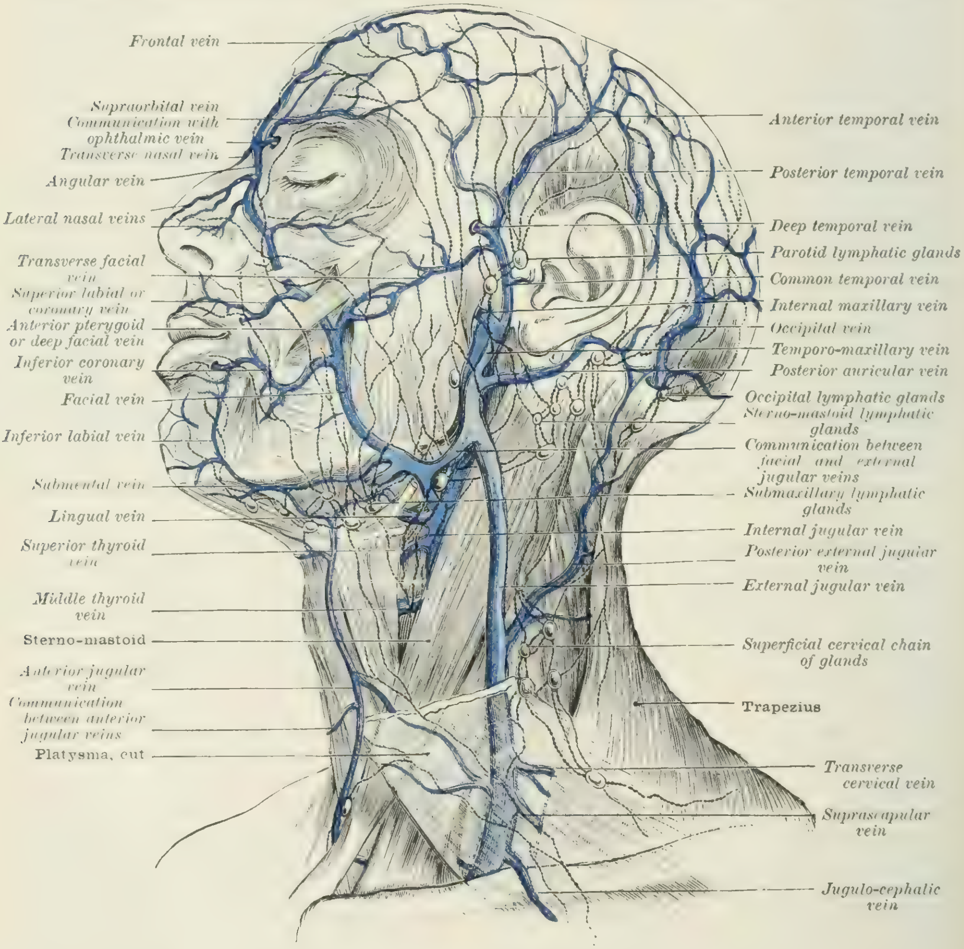
(3) The **parotid lymphatic glands** are situated just in front of the ear over the parotid salivary gland, in the substance of which one or more are embedded. They receive the temporal set of lymphatic vessels, and the lymphatics from the external parts of the eyelid and posterior and greater part of the cheek. They discharge, partly into the submaxillary glands, and partly into the superficial cervical chain.

(4) The **buccal lymphatic glands** are situated on the surface of the buccinator.

Some of the facial lymphatics pass through these on their way to the submaxillary glands.

(5) The **submaxillary lymphatic glands** are situated in the digastric triangle, beneath the body of the lower jaw. They vary from eight to twelve in number. They receive some of the lymphatics from the face, i.e. from the upper and lower lips and side of the nose; the lymphatics from the floor of the mouth, from the front part of the tongue, and from the sublingual and submaxillary salivary glands, and the anterior efferent vessels from the parotid lymphatic glands. Their efferent vessels terminate partly in the deep, and partly in the superficial cervical lymphatic glands. Two or three glands situated in the middle line between the anterior bellies of the digastric muscles are sometimes distinguished as the **suprahyoid** lymphatic glands.

Fig. 398.—The Superficial Lymphatics of the Scalp, Face, and Neck. (Walsham.)


Frontal vein
Supraorbital vein
Communication with ophthalmic vein
Transverse nasal vein
Angular vein
Lateral nasal veins
Transverse facial vein
Superior labial or coronary vein
Anterior pterygoid or deep facial vein
Inferior coronary vein
Facial vein
Inferior labial vein
Submental vein
Lingual vein
Superior thyroid vein
Middle thyroid vein
Sterno-mastoid
Anterior jugular vein
Communication between anterior jugular veins
Platysma, cut
Anterior temporal vein
Posterior temporal vein
Deep temporal vein
Parotid lymphatic glands
Common temporal vein
Internal maxillary vein
Occipital vein
Temporo-maxillary vein
Posterior auricular vein
Occipital lymphatic glands
Sterno-mastoid lymphatic glands
Communication between facial and external jugular veins
Submaxillary lymphatic glands
Internal jugular vein
Posterior external jugular vein
External jugular vein
Superficial cervical chain of glands
Trapezius
Transverse cervical vein
Suprascapular vein
Jugulo-cephalic vein

2. The **vertical set of superficial glands of the neck**—four to six in number, known as the **superficial cervical chain**—are situated chiefly in the posterior triangle of the neck, along the course of the external jugular vein, between the platysma and the deep fascia. Small superficial glands are also found in the front of the neck between the hyoid bone and the sternum, and posteriorly over the trapezius muscle. The superficial cervical glands receive the vessels from the occipital glands, and from the posterior auricular glands, and part of those from the parotid and submaxillary glands. They also receive the lymphatics from the

integuments of the neck and from the external ear. Their efferent vessels open into the deep chain of cervical glands.

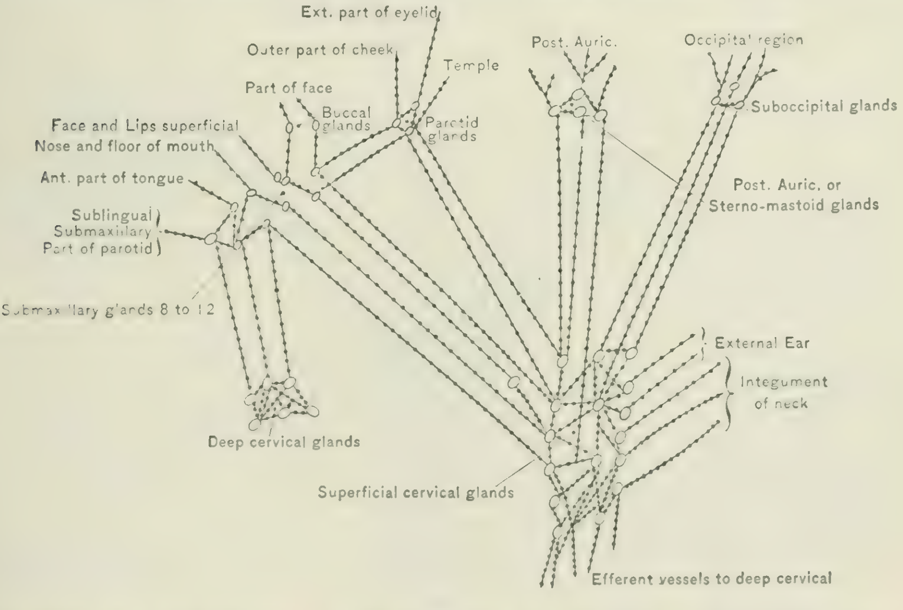
II. *THE DEEP LYMPHATIC VESSELS AND GLANDS OF THE HEAD AND NECK*

A. THE DEEP LYMPHATIC VESSELS OF THE HEAD AND NECK

The **deep lymphatic vessels of the head and neck** may be divided into the lymphatics of the cranium, the orbit, the temporal and zygomatic fossæ, the nose, the mouth and tongue, the pharynx, the larynx, the upper part of the œsophagus and trachea, and the thyroid body. They roughly follow the course of the deep arteries, and terminate in the deep cervical chain of lymphatic glands which accompany the common carotid artery and internal jugular vein.

1. The **lymphatics from the interior of the cranium** are divided into the meningeal and the cerebral. The **meningeal** accompany the meningeal arteries through the various foramina in the base of the skull, and terminate in the deep cervical chain. The **cerebral lymphatics** pass in like manner with the cerebral vessels (the internal carotid and vertebral arteries, and the internal jugular vein), through the corresponding foramina in the base of the skull, and join the deep lymphatic chain. The origin of the cerebral lymphatics and the lymphatics from the choroid plexus are described in the ANATOMY OF THE BRAIN (page 678).

FIG. 398A.—DIAGRAM OF THE SUPERFICIAL LYMPHATIC VESSELS AND GLANDS OF THE HEAD AND NECK. (After Drawing by Dr. Francis R. Sherwood.)


Ext. part of eyelid
Outer part of cheek
Temple
Post. Auric.
Occipital region
Part of face
Buccal glands
Parotid glands
Suboccipital glands
Face and Lips superficial
Nose and floor of mouth
Ant. part of tongue
Post. Auric. or Sterno-mastoid glands
Sublingual
Submaxillary
Part of parotid
Submaxillary glands 8 to 12
External Ear
Integument of neck
Deep cervical glands
Superficial cervical glands
Efferent vessels to deep cervical

2. The **lymphatics of the orbit** pass with the infraorbital vein into the spheno-maxillary fossa, and thence with the internal maxillary vein into the internal maxillary and deep parotid glands. (For description of the lymphatics of the eyeball, see page 852.)

3. The **lymphatics from the temporal and zygomatic fossæ** run with the arteries in these situations, and, after passing through the internal maxillary glands, join the deep cervical chain.

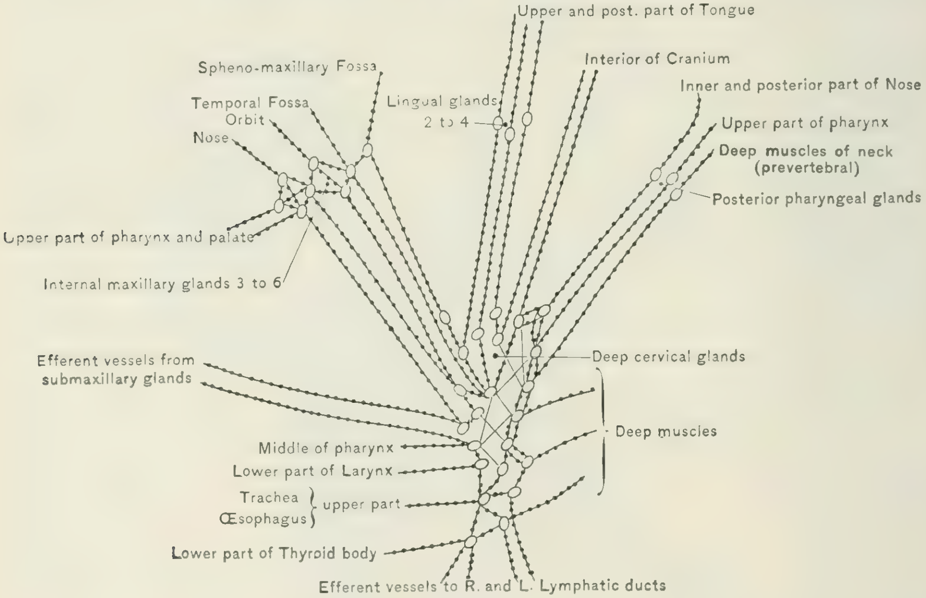
4. The **lymphatics from the interior of the nose** accompany the arteries supplying that cavity, and terminate, in part in the lymphatics of the pharynx, but chiefly in the deep cervical chain. They communicate, through the lymphatic

spaces which surround the olfactory nerves, with the subdural and subarachnoid lymph-spaces of the cranium.

5. **The lymphatics of the mouth and tongue.**—The lymphatics from the floor of the mouth pass through the mylo-hyoid muscle into the submaxillary lymphatic glands. The lymphatics of the lips pass with the superficial lymphatics, partly into the submaxillary glands, and partly into the deep cervical chain. The lymphatics of the deep surface of the cheek and of the roof of the mouth join the internal maxillary lymphatic glands. The lymphatics of the tongue run backwards with the ranine vein, and, after passing through several small lingual glands on the hyo-glossus muscle, join the deep cervical chain. The lymphatics of the front part of the tongue pass with the lymphatics of the floor of the mouth, through the mylo-hyoidean muscles into the submaxillary glands.

6. The **lymphatics of the pharynx** run along the course of the pharyngeal arteries and enter the upper set of deep cervical glands. Those from the upper part of the pharynx pass through the post-pharyngeal gland. The lymphatics of the tonsil open into the submaxillary glands near the angle of the jaw.

Fig. 398b.—Diagram of the Deep Lymphatic Vessels and Glands of the Head and Neck. (After Drawing by Dr. Francis R. Sherwood.)


Upper and post. part of Tongue
Interior of Cranium
Spheno-maxillary Fossa
Inner and posterior part of Nose
Temporal Fossa
Lingual glands 2 to 4
Orbit
Nose
Upper part of pharynx
Deep muscles of neck (prevertebral)
Posterior pharyngeal glands
Upper part of pharynx and palate
Internal maxillary glands 3 to 6
Deep cervical glands
Efferent vessels from submaxillary glands
Deep muscles
Middle of pharynx
Lower part of Larynx
Trachea
Œsophagus
upper part
Lower part of Thyroid body
Efferent vessels to R. and L. Lymphatic ducts

7. The **lymphatics of the larynx** join the deep cervical glands. Those above the glottis pierce the thyro-hyoid membrane, and end in the upper set of the deep cervical glands; those below the glottis perforate the crico-thyroid membrane, and, after passing through one or more small **laryngeal glands** at the lower part of the larynx on its anterior or lateral aspect, enter the lower set of the deep cervical glands.

8. The **lymphatics of the upper part of the œsophagus and trachea** join the lower glands of the deep cervical chain.

9. The **lymphatics of the thyroid body** accompany the thyroid arteries, and end in part in the upper and in part in the lower glands of the deep cervical chain.

B. The Deep Lymphatic Glands of the Head and Neck

1. The **deep lymphatic glands of the head** are few in number. They are the lingual, the internal maxillary, and the post-pharyngeal.

(1) The **lingual**, two to four in number, are situated on the outer surface of

the hyo-glossus and genio-hyo-glossus muscles. They receive lymphatics from the upper surface and posterior part of the substance of the tongue. Their efferent vessels terminate in the superior glands of the deep cervical chain.

(2) The **internal maxillary** or **deep facial glands,** three to six in number, are situated by the side of the pharynx immediately behind the buccinator muscle. They receive the lymphatics from the orbit, the nose, the temporal and spheno-maxillary fossæ, the upper jaw, the palate, and the pharynx. Their efferent vessels join the superior glands of the deep cervical chain.

(3) The **post-pharyngeal gland** is situated behind the pharynx on the rectus capitis anticus major near the base of the skull. It receives lymphatics from the upper part of the pharynx, from the nose, and from the deep prevertebral muscles.

2. The **deep lymphatic glands of the neck** are divided into the **upper** and the **lower.**

The **upper set** extend along the course of the internal jugular vein from the base of the skull to about the level of the thyroid cartilage. They receive the lymphatics from the interior of the cranium above; the lymphatics from the deep muscles of the upper part of the neck behind; and the lymphatics from the internal maxillary glands, the posterior half of the tongue, the middle portion of the pharynx, the upper part of the larynx, the upper part of the thyroid body, and some of the efferent vessels from the submaxillary lymphatic glands in front and internally. Their efferent vessels pass downwards to the lower deep cervical glands.

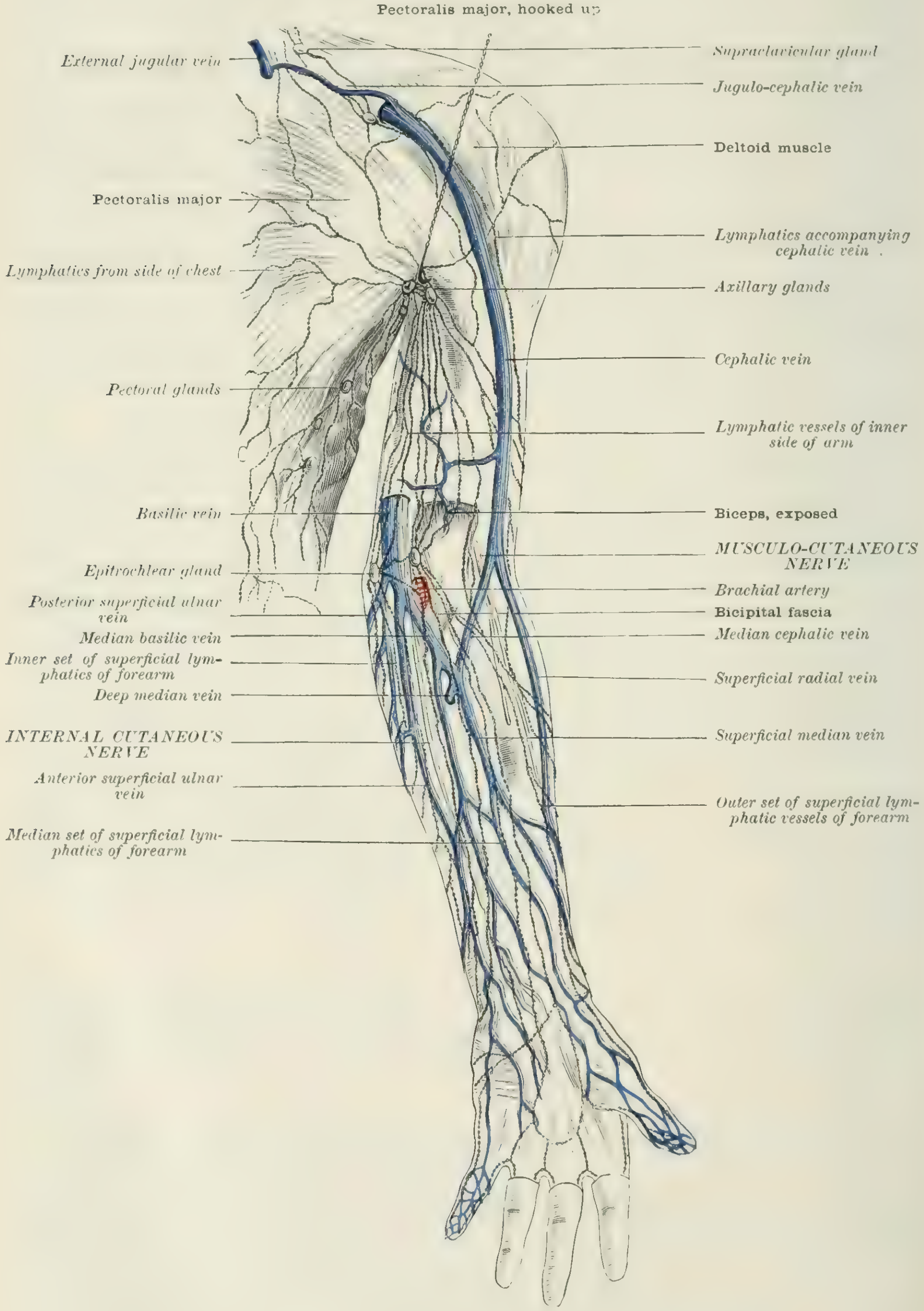
The **lower deep cervical glands** follow the course of the internal jugular vein from the thyroid cartilage to near the clavicle. They receive the lymphatics from the lower part of the neck, the efferent vessels from the superior set of deep cervical glands, the lymphatics from the lower part of the larynx, the lower part of the thyroid body, the upper part of the trachea and œsophagus, and the efferent vessels from the superficial cervical glands. Their efferent vessels end in the jugular lymphatic trunk, which unites with the subclavian lymphatic trunk, on the right side to form the right lymphatic duct, and on the left side to end in the thoracic duct. The right jugular trunk may also receive the lymphatics coming from the right half of the superior and anterior mediastina.

The right lymphatic duct.—The right lymphatic duct is a short vessel from half to three-quarters of an inch long. It receives the lymphatics from the right side of the head and neck, from the right upper extremity, most of the lymphatics from the right side of the thorax, the right lung and pleura and from the right side of the heart and part of the lymphatics from the convex surface of the liver. It passes downwards and inwards from its formation at the union of the subclavian and jugular lymphatic trunks, and ends at the confluence of the right internal jugular and subclavian veins. Its entrance is guarded by a double valve.

THE LYMPHATICS OF THE UPPER EXTREMITY

The **lymphatics of the upper extremity**—consisting of both lymphatic vessels and lymphatic glands—are arranged in two sets, a superficial and a deep. The former are situated in the subcutaneous tissue between the skin and the deep or muscular fascia, the latter along the course of the arteries of the limb. Both sets converge as they approach the axilla, and unite in the axillary glands. The efferent vessels of these glands form one or more trunks, which open, on the left side, into the thoracic duct, and, on the right side, into the right lymphatic duct.

FIG. 399.—THE SUPERFICIAL LYMPHATICS OF THE LEFT UPPER LIMB AND AXILLARY GLANDS. (Walsham.)


Pectoralis major, hooked up
External jugular vein
Supraclavicular gland
Jugulo-cephalic vein
Deltoid muscle
Pectoralis major
Lymphatics accompanying cephalic vein
Lymphatics from side of chest
Axillary glands
Cephalic vein
Pectoral glands
Lymphatic vessels of inner side of arm
Basilic vein
Biceps, exposed
MUSCULO-CUTANEOUS NERVE
Epitrochlear gland
Brachial artery
Posterior superficial ulnar vein
Bicipital fascia
Median basilic vein
Median cephalic vein
Inner set of superficial lymphatics of forearm
Superficial radial vein
Deep median vein
INTERNAL CUTANEOUS NERVE
Superficial median vein
Anterior superficial ulnar vein
Outer set of superficial lymphatic vessels of forearm
Median set of superficial lymphatics of forearm

I. *THE SUPERFICIAL LYMPHATIC VESSELS AND GLANDS OF THE UPPER EXTREMITY*

1. The **superficial lymphatic vessels** begin around the matrix of the nail and in the pulp of the finger. Thence they run upwards, in the form of four main channels, along the side of the finger—two on the dorsal and two on the palmar aspect.

The palmar set end on the convexity of a lymphatic palmar arch. From the arch, lymphatic vessels run up the forearm, more or less in two sets—an outer and an inner—roughly following the course of the superficial veins; a third or median set, starting as a plexiform arrangement in front of the wrist, runs up between the other two. The communication, however, between the three main sets of vessels is so free that, when they are minutely injected, the front of the forearm appears covered with a dense plexus of lymphatics (fig. 399).

The dorsal set of digital lymphatics ends in a plexus on the back of the hand. From this plexus numerous lymphatic vessels stream up the back of the forearm, and, winding round the inner and outer borders respectively of the limb, join the lymphatics on the anterior aspect.

From the bend of the elbow the lymphatics run up the arm, the greater number following the course of the basilic vein, and, dipping beneath the pectoralis major, converge to end in the axillary glands. The lymphatics from the outer side of the arm run in chief part obliquely across the biceps, towards the axilla; but a few accompany the cephalic vein to the infraclavicular lymphatic glands. The lymphatics over the deltoid also mainly end in these glands.

2. The **superficial lymphatic glands** are few in number. There are none, as a rule, below the bend of the elbow. Occasionally there is one at the bend of the elbow, and constantly two or three are found above the internal condyle (**epitrochlear glands**), in the course of the lymphatic vessels running with the basilic vein.

II. *THE DEEP LYMPHATIC VESSELS AND GLANDS OF THE UPPER EXTREMITY*

1. The **deep lymphatic vessels** accompany the arteries of the upper extremity. Hence in the forearm they are found along the course of the radial, the ulnar, the anterior interosseous, and the posterior interosseous arteries. At the bend of the elbow they converge, and follow the course of the brachial and axillary arteries to the axilla, and there end, together with the superficial lymphatics of the upper extremity and the superficial lymphatics from the side of the chest and back of the shoulder, in the axillary lymphatic glands. They communicate with the superficial lymphatics at the wrist.

2. **The deep lymphatic glands.**—A few small glands are occasionally found in the course of the lymphatic vessels accompanying the arteries of the forearm, and, more often, a few in the course of those accompanying the brachial artery. But the first important set of deep glands is met with in the axilla.

The **axillary glands** are numerous and of large size. They are about twelve in number. They are arranged in four chief sets—a median set, three or more in number, situated along the course of the axillary artery and vein (**axillary glands proper**); an inner or anterior set, four or five in number, situated below the greater pectoral muscles in the course of the long thoracic artery, on the outer surface of the serratus magnus (**pectoral glands**); a posterior or external set, usually two in number, situated along the course of the subscapular artery, under cover of the latissimus dorsi (**subscapular glands**); and a superior set, usually two in number, situated just below the clavicle close to the cephalic vein, upon the costo-coracoid membrane in the fossa beneath the pectoralis major and deltoid (**subclavian** or **infraclavicular glands**).

The axillary glands proper, or the glands along the course of the axillary artery and vein, receive the larger number of lymphatics from the arm. The pectoral glands receive the lymphatics from the mammary gland, the side of the chest, and the integument of the upper portion of the abdominal wall. The subscapular glands receive the lymphatics from the integuments of the back. The infra-clavicular glands receive the lymphatics from the outer part of the arm and integuments covering the deltoid. They communicate, above with the cervical lymphatics, and below with the other glands in the axilla. The efferent vessels from all these glands run upwards along the subclavian vein, and enter the neck either as four distinct trunks, or as a single trunk (the **axillary lymphatic trunk**), and terminate on the left side in the thoracic duct, and on the right side in the right lymphatic duct.

The communication between the glands in the axilla is very free. Thus, in secondary infiltration following carcinoma of the breast, although the pectoral glands may at first be alone affected, the remaining sets generally become also involved.

THE LYMPHATICS OF THE THORAX

The **lymphatics of the thorax** may be divided into the parietal, which ramify in the thoracic walls; and the visceral, which receive the lymph from the thoracic viscera. The thoracic duct, which conveys the lymph from the lower extremities and from the greater part of the abdomen, passes through the posterior mediastinum on its way to the confluence of the left internal jugular and subclavian veins at the root of the neck, and is described here with the lymphatics of the thorax.

I. *THE PARIETAL LYMPHATIC VESSELS AND GLANDS OF THE THORAX*

1. The **parietal lymphatic vessels** are divided into the superficial and the deep.

The **superficial parietal lymphatics** ramify beneath the integuments, over the pectoralis major in front, the serratus magnus laterally, and the trapezius and latissimus dorsi behind. They all converge towards the axilla, and end in the axillary glands. The **lymphatics of the mammary gland** end for the most part in the pectoral set of the axillary glands, but those from the inner portion of the gland pass through the second, third, and fourth intercostal spaces into the internal mammary lymphatic chain of glands, and thus open into the thoracic duct on the left, and the right lymphatic duct on the right side. According to Macalister, the lymphatics from the nipple and areola pass more deeply into the axilla, and end in one of the axillary glands, placed nearer to the clavicle than the pectoral set.

The **deep parietal lymphatics** are subdivided into (1) the intercostal and (2) the diaphragmatic.

(1) The **intercostal lymphatics** accompany the intercostal arteries and receive the lymph from the intercostal muscles and the parietal pleura. Those in the anterior part of the intercostal space run forwards and end in the internal mammary or anterior intercostal lymphatic glands. Those in the posterior part of the space run backwards, and—after receiving the dorsal lymphatic vessels which accompany the dorsal branches of the intercostal arteries between the transverse processes of the vertebræ, and return the lymph from the muscles of the back and from the spinal canal—end in the intercostal or posterior intercostal lymphatic glands.

(2) The **diaphragmatic lymphatics** follow the vessels of the diaphragm. They terminate, anteriorly in the internal mammary and anterior mediastinal lymphatic glands; postero-laterally in the lower intercostal lymphatics and in the lymphatics accompanying the musculo-phrenic artery; and posteriorly in the pos-

terior mediastinal glands. The lymphatics from the vertebral portion of the diaphragm end in the lumbar glands (see Lymphatics of Abdomen, page 661). Some of the lymphatics from the right side join the hepatic lymphatics.

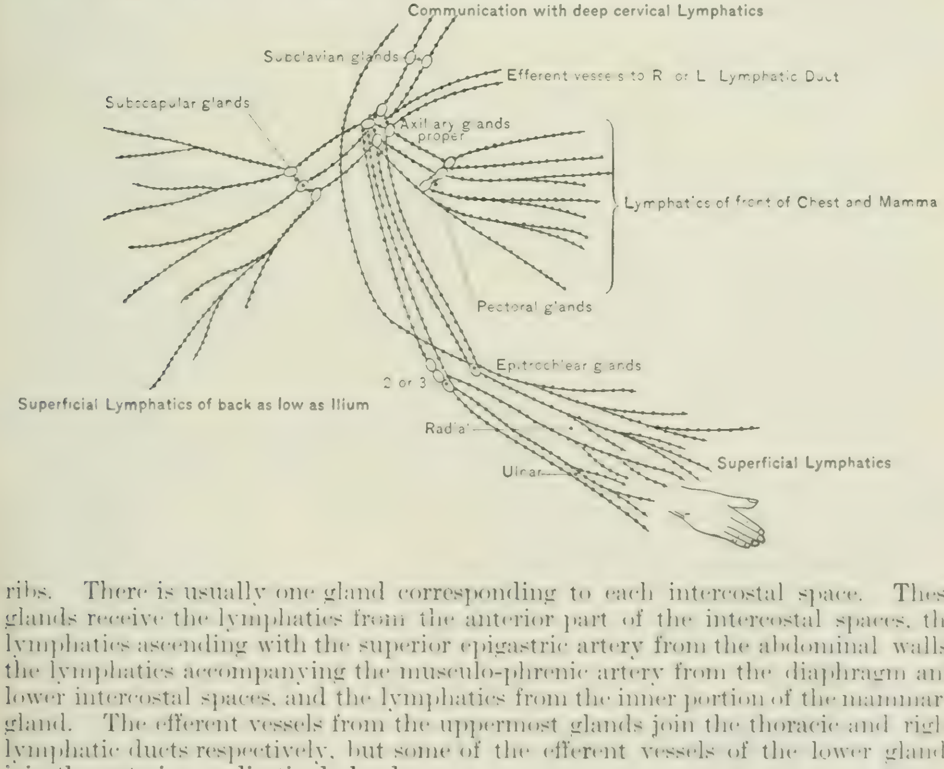
2. The **parietal lymphatic glands** are also divided into the superficial and the deep.

The superficial parietal glands.—The three or four glands along the lower border of the pectoralis major, described here as the pectoral set of the axillary glands, are by some authors classed as superficial thoracic glands. They receive the lymphatics from the front of the chest, and some of the lymphatics of the mammary gland. There is also occasionally a superficial gland a little below the ensiform cartilage called the **epigastric gland.** It receives, when present, some of the lymphatics from the lower anterior chest walls and upper part of the abdomen.

The **deep parietal glands** are:—(1) The internal mammary, sternal, or anterior intercostal; and (2) the intercostal or posterior intercostal.

(1) The **internal mammary, sternal,** or **anterior intercostal glands** lie along the course of the internal mammary artery behind the costal cartilages of the true ribs. There is usually one gland corresponding to each intercostal space. These glands receive the lymphatics from the anterior part of the intercostal spaces, the lymphatics ascending with the superior epigastric artery from the abdominal walls, the lymphatics accompanying the musculo-phrenic artery from the diaphragm and lower intercostal spaces, and the lymphatics from the inner portion of the mammary gland. The efferent vessels from the uppermost glands join the thoracic and right lymphatic ducts respectively, but some of the efferent vessels of the lower glands join the anterior mediastinal glands.

Fig. 399a.—Diagram of the Superficial and Deep Lymphatic Vessels and Glands of the Upper Extremity including the Superficial Lymphatic Vessels of the Back and Chest. (After Drawing by Dr. Francis R. Sherwood.)


Communication with deep cervical Lymphatics
Subclavian glands
Efferent vessels to R. or L. Lymphatic Duct
Subscapular glands
Axillary glands proper
Lymphatics of front of Chest and Mamma
Pectoral glands
Epitrochlear glands
2 or 3
Superficial Lymphatics of back as low as Ilium
Radial
Ulnar
Superficial Lymphatics

(2) The **intercostal** or **posterior intercostal lymphatic glands** lie in the posterior end of each intercostal space about the level of the heads of the ribs. They receive the lymphatics accompanying the intercostal vessels from the posterior parts of the intercostal spaces, and the lymphatics from the deep muscles of the back, and from the spinal canal. The lowermost also receive some of the lymphatics from the diaphragm. On the left side their efferent vessels open into the thoracic duct. On the right side the efferent vessels from the lower glands also join the thoracic duct, but the vessels from the upper glands may join the efferent vessels from the bronchial glands (the **bronchio-mediastinal trunk**) and open into the right lymphatic duct.

II. *THE VISCERAL LYMPHATIC VESSELS AND GLANDS OF THE THORAX*

1. The **visceral lymphatics of the thorax** include those from the heart and pericardium, the lungs and visceral pleura, the œsophagus and the thymus gland, with the glands into which these lymphatics respectively open—namely, the anterior mediastinal, the superior mediastinal, the posterior mediastinal, and the bronchial.

The **lymphatics of the pericardium** end in front in the anterior mediastinal and superior mediastinal glands, and behind in the posterior mediastinal glands.

The **lymphatics of the heart** begin at the apex, and follow the coronary vessels to the base, where they leave the pericardium, and unite to form a right and a left trunk. The former passes over the arch of the aorta, then through one of the superior mediastinal or cardiac glands, and thence backwards to the trachea, on which it runs to join the right lymphatic duct at the root of the neck. The left trunk courses along the pulmonary artery, and, at the bifurcation of that vessel, passes through one of the posterior mediastinal glands behind the arch of the aorta, and thence runs up the left side of the trachea to end in the thoracic duct.

The **lymphatics of the visceral pleura and lung** form a superficial set beneath the pleura, and a deep set which accompanies the pulmonary vessels and bronchial tubes. At the root of the lung the superficial join the deep, which then enter the bronchial glands.

The **lymphatics of the thoracic portion of the œsophagus** begin as a plexus between the mucous membrane and the muscular coat, perforate the latter, and terminate in the posterior mediastinal glands.

The **lymphatics of the thymus** terminate in the superior mediastinal glands.

2. The **visceral lymphatic glands** are the anterior mediastinal, the superior mediastinal, the posterior mediastinal, and the bronchial.

The **anterior mediastinal** or **sternal glands** lie in front of the pericardium behind the sternum in the loose tissue of the anterior mediastinum. They receive the lymphatics from the antero-median portion of the diaphragm, the front of the pericardium and heart, some of the efferent vessels from the lower internal mammary lymphatic glands, and the lymphatics from the convex surface of the right lobe of the liver. Their efferent vessels pass upwards to the superior mediastinal glands.

The **superior mediastinal** or **cardiac glands** lie in front of the upper part of the pericardium, the arch of the aorta, and left innominate vein. They receive the lymphatics from the anterior mediastinal glands, from the upper and front part of the pericardium and right side of the heart, and from the thymus gland. Their efferent vessels run up the sides of the trachea to join the thoracic duct and right lymphatic duct respectively.

The **posterior mediastinal glands** are situated in the posterior mediastinum along the course of the aorta and œsophagus. They receive lymphatics from the back of the pericardium and left side of the heart, from the œsophagus, from the posterior part of the diaphragm, and a few from the right border of the liver. Their efferent vessels pass chiefly into the thoracic duct; a few into the bronchial glands.

The **bronchial glands** are placed between the divisions of the bronchi at the root of the lung (**pulmonary glands**), and about the bifurcation of the trachea (**tracheal glands**). The larger glands, situated at the bifurcation of the trachea, are twenty or thirty in number. They receive the lymphatics from the lung and visceral pleura; also some of the lymphatics from the trachea and from the back of the heart and pericardium, and a few of the efferent vessels of the posterior mediastinal glands. Their efferent vessels, with the efferent vessels of the superior mediastinal or cardiac glands, pass up the sides of the trachea, and on the right side either terminate directly in the right lymphatic duct, or join with the efferent vessels of the intercostal glands to form a common trunk, the **broncho-mediastinal trunk,** and thus open into the right lymphatic duct. On the left side they open directly into the thoracic duct, or first form, as on the right side, a broncho-mediastinal trunk.

In early life they are of a pinkish colour, but as life advances they become bluish, and later almost black, from the deposit of pigment arrested in them in its passage from the lungs.

THE THORACIC DUCT

The **thoracic duct** begins in the abdomen at the receptaculum chyli opposite the first or second lumbar vertebra, enters the thorax through the aortic opening of the diaphragm, runs up the posterior mediastinum to the right of the aorta, crosses behind the aortic arch, and, leaving the thorax at the superior opening, ascends on the left side of the neck as high as the seventh cervical vertebra, and, finally curving over the apex of the left pleura and subclavian artery, ends in the confluence of the left internal jugular and subclavian veins.

The duct is about eighteen inches long, and pursues a tortuous course. It contains many double valves which, when the duct is dilated, cause it to be constricted at intervals, and give it somewhat the appearance of a string of beads. The valves are more numerous in the upper than in the lower part of the duct. At its entrance into the innominate vein there are two perfect valves, which effectually prevent any regurgitation of lymph or entrance of blood. The calibre of the duct usually decreases as it ascends through the thorax, but increases again at its upper part. It is least at or about the fifth thoracic vertebra. The thoracic duct conveys the lymph from the lower extremities, the lymph and chyle from the abdomen (except some of the lymph from the convex surface of the liver), the lymph from the left side of the thorax, and some of that from the right side, and the lymph from the left upper extremity and the left side of the head and neck.

The **relations of the thoracic duct** in the abdomen, the thorax, and at the root of the neck, may be considered separately.

1. The **abdominal portion of the thoracic duct** lies deeply placed behind and between the aorta and the right crus of the diaphragm on the front of the body of the second lumbar vertebra. This part of the duct is dilated into an irregular, sacculated, and fusiform sac, known as the **receptaculum chyli,** or **cistern of Pecquet.** It receives the efferent vessels of the lumbar glands, the intestinal lymphatic trunk, and sometimes some of the hepatic and gastric lymphatics. It is thin-walled and contains no valves, and is about an inch and a half long (38 mm.) and about a quarter of an inch in diameter at its widest part (7 mm.). As the duct passes through the aortic opening of the diaphragm, it still lies to the right of the aorta, and has the vena azygos major to its right side.

2. The **thoracic portion of the thoracic duct** lies at first in the posterior mediastinum between the aorta and the vena azygos major, in front of the seven lower thoracic vertebræ; but at the level of the fifth thoracic vertebra it passes to the left behind the œsophagus and aortic arch, and enters the superior mediastinum, whence it escapes through the upper aperture of the thorax into the root of the neck. This portion of the duct is not of equal calibre throughout; as a rule, it is contracted in some places and dilated at others. The constrictions indicate the situation of the valves.

In the **posterior mediastinum** it has in front of it, from below upwards, the pericardium, the œsophagus, and the arch of the aorta; behind it, the seven lower thoracic vertebræ, the anterior common ligament, the lower right intercostal arteries, the vena azygos minor, and at times one or more of the mid left intercostal veins, and the vena azygos tertia. To its left is the thoracic aorta, and to its right the vena azygos major and the right pleura. In the **superior mediastinum** it ascends, between the œsophagus and left pleura, to the posterior and left side of the superior thoracic opening. It here has in front of it the first portion of the left subclavian artery, behind it the upper thoracic vertebræ, to its left the pleura, and to its right the œsophagus.

Opening into the thoracic portion of the duct are:—the lymphatics from the left half of the thoracic walls; the efferent vessels from the left anterior mediastinal and intercostal glands; the lymphatics of the left lung and the left side of the heart; the lymphatics of the trachea and œsophagus, and the right lower internal mammary lymphatics.

3. The **cervical portion of the thoracic duct** ascends as high as the level of the seventh cervical vertebra, and then curves, downwards and forwards, over the apex of the pleura in front of the subclavian artery, scalenus anticus muscle, and vertebral vein, behind the left internal jugular vein, and behind and subsequently external to the left common carotid artery, and, having received the left jugular lymphatic trunk, opens into the left innominate vein at the confluence of the internal jugular and subclavian veins. The cervical portion receives the lymphatics from the left upper extremity and left side of the head and neck.

The chief variations in the thoracic duct.—(1) The thoracic duct may be double; when this is the case, the left duct may end normally in the left innominate vein, and the right in the corresponding situation on the right side; or the two ducts may unite at the root of the neck, and open into the left innominate vein. (2) The reduplication may be incomplete. Thus: (*a*) The duct may at first be single, but divide into two separate vessels at a variable distance from its termination, and then (i) one branch of the duct may enter the left confluence of veins at the root of the neck: the other the right confluence, a normal condition in some animals; or one may enter the confluence of veins in the normal manner, the other either the subclavian or internal jugular vein; or (ii) the two branches may reunite—this is a frequent variety, and is regarded as a normal condition by some anatomists. (*b*) It may break up into several branches in its course through the thorax, forming a plexus of vessels, which subsequently reunite into a single duct. (3) The thoracic duct may lie altogether to the left side of the aorta, and terminate as normal. (4) The duct may open into the confluence of the subclavian and internal jugular veins on the right side, an abnormal arrangement which may occur under the following conditions:—(*a*) when the viscera are transposed; (*b*) when there is a right aortic arch without transposition of viscera; and (*c*) when the vessels and viscera are normal. (5) The duct may end in the vena azygos major.

THE LYMPHATICS OF THE ABDOMEN AND PELVIS

The **lymphatics of the abdomen and pelvis** may be divided into the parietal, which ramify in the abdominal and pelvic walls; and the visceral, which receive the lymph from the pelvic viscera, and the lymph and chyle from the abdominal viscera.

I. *THE PARIETAL LYMPHATIC VESSELS AND GLANDS OF THE ABDOMEN AND PELVIS*

1. The **parietal lymphatic vessels** may be subdivided into the **superficial,** which ramify beneath the skin in the subcutaneous tissue, and include the lymphatics of the skin of the penis and scrotum and of the external genital organs in the female; and into the **deep,** which accompany the deep arteries of the abdominal and pelvic walls. The former for the most part end in the superficial inguinal glands; the latter in the lumbar glands.

(1) **The superficial parietal lymphatics.**—The superficial parietal lymphatics of the abdominal walls are situated between the skin and the abdominal muscles. Those from the **front** of the abdomen, below the level of the umbilicus, pass downwards along the course of the superficial epigastric artery and veins, and end in the superficial inguinal glands. The lymphatics from the upper part of the front of the abdomen, above the level of the umbilicus, pass upwards and outwards with the lymphatics from the front and side of the chest to the axillary glands. The lymphatics from the **lateral** abdominal walls run, in part over the crest of the ilium, in the course of the superficial circumflex iliac artery and veins, into the outer superficial inguinal glands, and in part follow the course of the lumbar and ilio-lumbar arteries, and, after perforating the abdominal muscles, end in the lateral lumbar glands. The superficial lymphatics from the lower part of the **back** and from the **gluteal region** for the most part pass outwards over the gluteal muscles to end in the outermost superficial inguinal glands; but those from the region of

the anus follow the course of the perinæal lymphatics through the fork to the innermost superficial inguinal glands.

The **superficial lymphatics of the penis** begin in the prepuce, and thence pass backwards to the corona glandis, where they form a ring around the glans. This ring receives the superficial lymphatics from the glans, and the lymphatics from the anterior two-thirds of the urethra which run from behind forwards. From the glans three main lymphatic channels run backwards under the integuments of the penis, one on the dorsum, and one on each side of the organ. At the root of the penis the dorsal lymphatic vessel divides into a right and a left branch, each branch passing with the lateral lymphatic vessel of the corresponding side to the superficial inguinal glands. The deep lymphatics of the penis pass with the dorsal vein into the pelvis, where they join the lymphatic glands about the internal iliac artery.

The **lymphatics of the scrotum** in the male, and of the parts corresponding thereto in the female, and the lymphatics of the other external generative organs in the female, run with the superficial external pudic arteries to the superficial inguinal glands. It will be noted that the lymphatics of the testicle pass with the spermatic artery to the lumbar glands.

The **superficial lymphatics of the perinæum** run upwards over the adductor muscles, through the fork between the thighs, and join the superficial inguinal glands.

(2) **The deep parietal lymphatics.**—The deep lymphatics of the **anterior** and **lateral abdominal walls** accompany the parietal vessels to the back of the abdomen, where they end in the deep glands. Thus some follow the deep epigastric artery to the external iliac glands; others the deep circumflex iliac artery also to the external iliac glands; and others, again, the ilio-lumbar and lumbar arteries to the lateral lumbar glands. The last are also joined by the lymphatics from the muscles of the back and from the spinal cord. The deep lymphatics from the upper part of the abdominal wall pass, with the superior epigastric artery, into the thorax, where they end in the internal mammary lymphatic glands.

The deep lymphatics of the **pelvic walls** accompany the parietal vessels, and hence are found with the obturator, sciatic, gluteal, pudic, and sacral arteries. They end in the glands surrounding the internal iliac artery, and in the sacral glands.

2. The **parietal lymphatic glands** lie, for the most part, along the back of the abdomen and pelvis, and are known, from their position, as the external iliac, internal iliac, sacral, lumbar, and cœliac glands.

The **external iliac lymphatic glands** lie along the course of the external iliac and common iliac arteries and veins. They are three to five or more in number. They receive the lymphatics from the inguinal glands and femoral glands, and the deep lymphatic vessels accompanying the deep epigastric and deep circumflex iliac arteries and veins from the anterior and lower abdominal walls. Their efferent vessels join the lumbar glands. They communicate with the internal iliac glands.

The **internal iliac glands** are situated in the course of the internal iliac artery and its branches. They vary from nine to twelve or more in number, the largest being situated at the upper part of the great sciatic foramen. They receive the lymphatics from the muscles of the pelvis and the lymphatics corresponding to the branches of the internal iliac artery. Thus the greater number of the lymphatics from the pelvic viscera, from the deeper parts of the perinæum, and from the hinder and deeper parts of the scrotum or labia majora, the deep lymphatics of the penis and posterior part of the urethra, the deep lymphatics from the gluteal region, and some of the lymphatics from the adductor muscles of the upper part of the thigh, join these glands. Their efferent vessels pass to the lumbar glands.

The **sacral glands** are situated in the hollow of the sacrum, four or five being placed in the meso-rectal folds opposite its promontory. They receive the lymphatics from the rectum and the hinder walls of the pelvis. They join the lumbar glands.

The **lumbar glands** lie beneath the peritoneum, at the back of the abdomen, on the front and sides of the lumbar vertebræ. They are usually divided into three groups, a median and two lateral; but these freely communicate with one another across the aorta and vena cava.

The **median group** (**aortic lumbar glands**) consists of about six large glands placed along the abdominal aorta and vena cava. They extend from the bifurcation of the aorta to the second lumbar vertebra.

The median group receive the efferent vessels of the external and internal iliac and sacral glands, the lymphatics accompanying the spermatic or ovarian vessels from the testicle or ovarian plexus respectively, and the lymphatics of the kidneys, suprarenal bodies, and hinder portion of the diaphragm. They also receive most of the efferent vessels from the lateral sets. Their efferent vessels commonly unite about the level of the second lumbar vertebra to form a right and a left **lumbar lymphatic trunk,** which open, with some small vessels from the lateral sets, into the receptaculum chyli. The left lumbar trunk also receives the lymphatics of the descending colon and sigmoid flexure.

The **lateral lumbar glands, transverse lumbar** or **psoas glands,** are situated behind the psoas between the transverse processes of the lumbar vertebræ. They are twenty or thirty in number, and smaller than the glands of the central group. The lateral glands receive the lymphatics accompanying the lumbar arteries, the lymphatics from the muscles of the back, the spinal canal, and from the deeper parts of the parietes of the posterior abdominal walls. Their efferent vessels open, in part into the median set, and in part, as separate vessels, into the receptaculum chyli.

The **cœliac glands,** sixteen to twenty in number, are grouped around the cœliac axis in front of the aorta, above the origin of the superior mesenteric artery. At the back of the transverse meso-colon they receive the efferent vessels from some of the hepatic glands, the superior gastric glands, the inferior gastric glands, the splenic and the pancreatic glands. Their efferent vessels join the intestinal lymphatic trunk, and open into the receptaculum chyli.

II. *THE VISCERAL LYMPHATIC VESSELS AND GLANDS OF THE ABDOMEN AND PELVIS*

The lymphatics of the pelvic and abdominal viscera are considered separately.

1. **The lymphatics of the pelvic viscera.**—The **lymphatics of the bladder** pass partly backwards, beneath the peritoneum, to join the rectal lymphatics, or the lymphatics of the uterus and vagina in the female; and partly forwards, to join the prostatic lymphatics and the lymphatics of the vesiculæ seminales. These anterior sets of lymphatics, together with those from the prostate and vesiculæ seminales, pass through the anterior true ligaments of the bladder, in which there is a small gland, into the internal iliac lymphatics.

The **lymphatics of the rectum** run backwards between the two layers of the meso-rectum, in which there are four or five glands, through the sacral to the lumbar glands. At the lower part of the rectum the lymphatics become continuous with the cutaneous lymphatics round the anus, and for this reason disease of the lower part of the bowel involves the inguinal glands.

The lymphatics of the uterus, vagina, ovaries, and Fallopian tubes.—The superficial lymphatics of the uterus, which lie beneath the peritoneum, pass, together with those of the substance of the fundus and upper part of the body of the organ, outwards, in the broad ligament, where they join the lymphatics from the ovaries and Fallopian tubes, and pass up, with the ovarian vessels, to the lumbar glands. The lymphatics from the lower part of the body and from the cervix of the uterus run, together with most of the lymphatics of the vagina, along the course of the uterine and vaginal vessels, and terminate in the internal iliac glands. The lymphatics from the lower part of the vagina join the superficial inguinal glands.

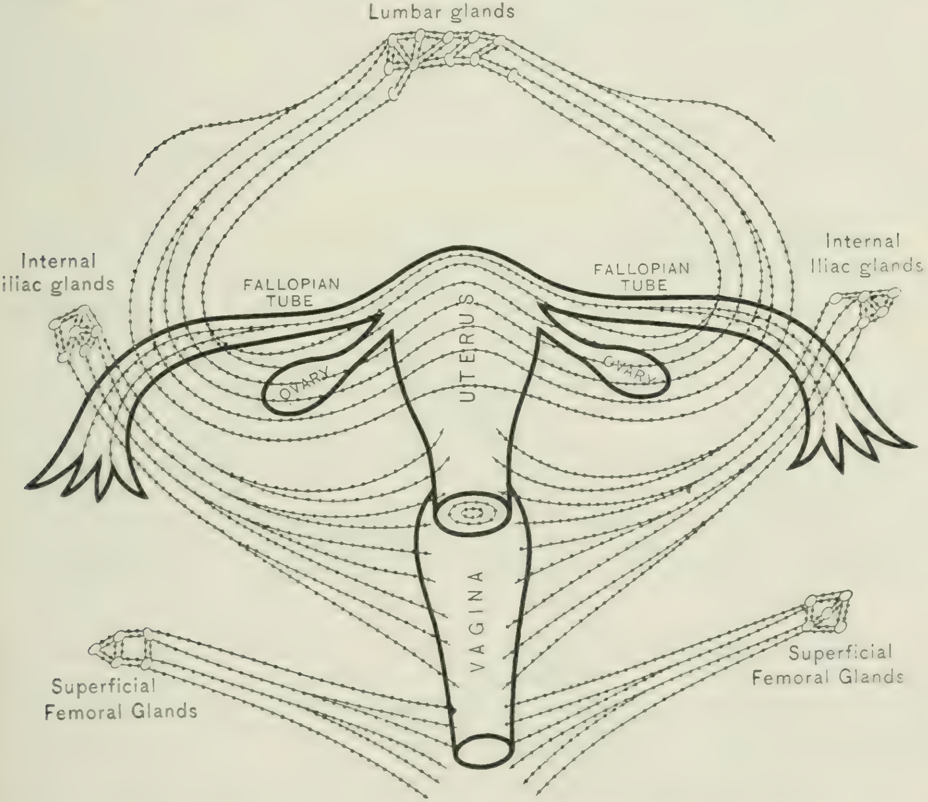
The **lymphatics of the testicle** accompany the spermatic vessels, and terminate in the lumbar glands situated immediately below the renal arteries. Hence in carcinoma of the testicle the lumbar glands are those which first become enlarged, the inguinal not being affected until the skin of the scrotum becomes involved in the disease.

2. The **lymphatics of the abdominal viscera** are divided into—(1) The

lymphatics of the stomach; (2) the intestines; (3) the liver; (4) the spleen; (5) the pancreas; (6) the kidneys; (7) the ureters; and (8) the suprarenal capsules.

(1) The **lymphatics of the stomach** begin in the mucous and subserous coat, and thence follow the course of the blood-vessels. Thus some run upwards to the lesser curve of the stomach, others downwards to the greater curve, and others leftwards to the greater end. In this way, three chief sets are formed—the superior gastric, the inferior gastric, and the left gastric lymphatics. (*a*) The **superior gastric** follow the course of the coronary vein along the lesser curvature towards the cardiac end of the stomach, lying between the layers of the lesser omentum. They pass on their way through five or six small (superior gastric) lymphatic glands. Reaching the cardia, they turn downwards, and, having been joined by some of the lymphatics from the left lobe of the liver, enter the upper cœliac glands. (*b*) The **inferior gastric lymphatics** follow the course of the right gastro-epiploic vessels towards the pylorus, along the greater curvature of the stomach, between the layers of the greater omentum. After passing through six or eight small glands (inferior gastric), they are joined by the lymphatics from the upper part of the duodenum, and run between the pylorus and pancreas to the cœliac glands. (*c*) The **left gastric lymphatics** run with the vasa brevia, between the folds of the gastro-splenic omentum, to the splenic lymphatic glands.

FIG. 399B.—DIAGRAM OF THE ARRANGEMENT OF THE LYMPHATICS OF THE UTERUS, FALLOPIAN TUBES, OVARIES, VAGINA, AND EXTERNAL VULVA. (After Drawing by Dr. Francis R. Sherwood.)



The **lymphatic glands of the stomach** are the superior and inferior gastric glands.

The **superior gastric glands**, five or six in number, are situated along the lesser curve between the layers of the gastro-hepatic omentum. They receive the superior gastric lymphatics; their efferent ducts pass first upwards towards the œsophagus, and then, after receiving the lymphatics from the upper and left portion of the left lobe of the liver, turn downwards behind the pancreas to join the cœliac glands.

The **inferior gastric** or **gastro-epiploic glands**, six or eight in number, lie along the greater curve of the stomach between the layers of the great omentum. They receive the inferior gastric lymphatics and the lymphatics of the great omentum. Their efferent vessels pass with the lymphatics from the upper part of the duodenum into the cœliac glands.

(2) The **lymphatic vessels of the intestine** are divided into the lymphatics of the small intestine and the lymphatics of the large intestine.

The **lymphatics of the small intestine** are called the **lacteals,** because they carry the chyle as well as the lymph from the intestinal walls. Beginning partly beneath the peritoneal coat—but chiefly in two plexuses, one between the muscular coats, and one beneath the mucous membrane—they pass round the intestine with the blood-vessels to the mesenteric attachment, and thence between the layers of the mesentery to the mesenteric glands.

The **lymphatics of the large intestine** are disposed of as follows:—(*a*) Those from the cæcum and ascending colon pass between the layers of the meso-colon to the meso-colic glands. (*b*) Those from the transverse colon and upper half of the descending colon pass with the middle colic artery between the layers of the meso-colon, also to the meso-colic glands. (*c*) Those from the lower half of the descending colon and sigmoid flexure pass into the left lymphatic trunk of the lumbar glands. The lymphatics of the rectum are described with the lymphatics of the pelvis (page 662).

The **lymphatic glands of the intestines** are the mesenteric and meso-colic.

The **mesenteric glands,** some one hundred and fifty to two hundred in number, lie between the layers of the mesentery. They are arranged roughly in three sets: (*a*) A primary set, about two inches from the intestinal margin of the mesentery, receive the lymphatics from the intestine. The efferent vessels from these glands pass into the next or secondary set. (*b*) The secondary set are situated about the primary loops of the superior mesenteric artery; they are more numerous than the primary set, and receive the efferent vessels of the latter. Their efferent vessels end in the tertiary set. (*c*) The tertiary set of glands lie along the course of the trunk of the superior mesenteric artery. They are larger than the secondary set, and closer together. Their efferent vessels unite to form three or four trunks, or perhaps more often a single trunk (the **intestinal lymphatic trunk**) which, after receiving the efferent vessels from the meso-colic glands, opens, either separately, or together with the efferent ducts of the cœliac glands, into the receptaculum chyli.

The glands and lacteals of the jejunum are more numerous than those of the ileum.

The **meso-colic glands,** twenty to thirty in number, are placed between the layers of the meso-colon. They receive the lymphatics from the cæcum, ascending and transverse colon, and from part of the descending colon. Their efferent vessels join the efferent vessels from the tertiary set of mesenteric glands, and open with them into the receptaculum chyli.

(3) The **lymphatics of the liver** consist of a superficial and deep set. The former are arranged in a plexus beneath the peritoneal covering; the latter accompany the blood-vessels in the substance of the organ.

(*a*) The **superficial set of lymphatics** form groups, and run in various directions. Those on the **upper** or **convex surface** of the liver are disposed of as follows:—(i) The lymphatics of the left half of the right lobe, and of the right half of the left lobe, converge towards the falciform ligament, up which they run to the diaphragm. They then pass through the costo-xiphoid space, and enter the anterior mediastinal chain of glands, and thus open in part into the right lymphatic duct. (ii) The lymphatics on the anterior part of the convex surface pass over the anterior margin, and along the course of the longitudinal fissure to the hepatic glands in the gastro-hepatic omentum. (iii) The lymphatics along the posterior margin of the liver pass between the layers of the coronary ligament to the diaphragm, which they perforate, and end in small glands about the upper part of the vena cava (Quain). (iv) A group from the right half of the right lobe pass outwards and backwards to the right lateral ligament, where they either perforate the diaphragm and end in the anterior mediastinal glands, or cross its crus and open into the cœliac glands or receptaculum chyli. (v) A group from the left half of the left lobe pass through the left lateral ligament, and join the œsophageal lymphatics at the œsophageal opening of the diaphragm, or pass with the superior gastric lymphatics behind the pancreas to the cœliac glands. Or they may pierce the diaphragm and enter the glands in the anterior mediastinum.

The **superficial lymphatics on the under surface of the liver** are arranged as follows:—(i) The greater number converge to the transverse fissure, and thence pass with the deep lymphatics to the hepatic glands in the gastro-hepatic omentum; (ii) a group from the back of the right lobe pass to the lumbar glands; (iii) a group from the back of the left lobe join the œsophageal lymphatics or superior gastric lymphatics, and end with them in the cœliac glands; (iv) the lymphatics of the gall-bladder run with the hepatic artery to the hepatic glands in the gastro-hepatic omentum.

(*b*) The **deep set of lymphatics** run, in part with the portal vein, and in part with the hepatic vein. (i) The portal set emerge at the transverse fissure, and pass with the blood-vessels to the hepatic glands in the gastro-hepatic omentum. (ii) The hepatic set perforate the diaphragm with the inferior vena cava, and, having passed through some small glands round the upper part of that vessel, join the superficial lymphatics from the posterior margin of the liver, and with them run down the thoracic surface of the vertebral portion of the diaphragm to the commencement of the thoracic duct or receptaculum chyli.

The **hepatic glands** are situated in front of the portal vein between the layers of the gastro-hepatic omentum. They receive the deep portal set of lymphatics, the anterior group of the superficial lymphatics from the convex surface of the liver, most of the superficial lymphatics from the under surface of the liver, and the lymphatics from the gall-bladder. Their efferent vessels proceed to the cœliac glands.

(4) **The lymphatics of the spleen.**—The splenic lymphatics are arranged in a superficial set which ramify beneath the peritoneal covering; and in a deep set, which run with the vessels in the parenchyma of the organ. Both sets unite at the hilum, and terminate in the splenic glands.

The **splenic glands,** eight to ten in number, are situated in the hilum of the spleen, and along the course of the splenic artery and vein. They receive the superficial and deep lymphatics of the spleen, and the left gastric lymphatics which run with the vasa brevia in the gastro-splenic omentum from the greater end of the stomach. The efferent vessels run behind the peritoneum and pancreas with the splenic artery to the cœliac glands. They are joined on the way by the lymphatics of the pancreas.

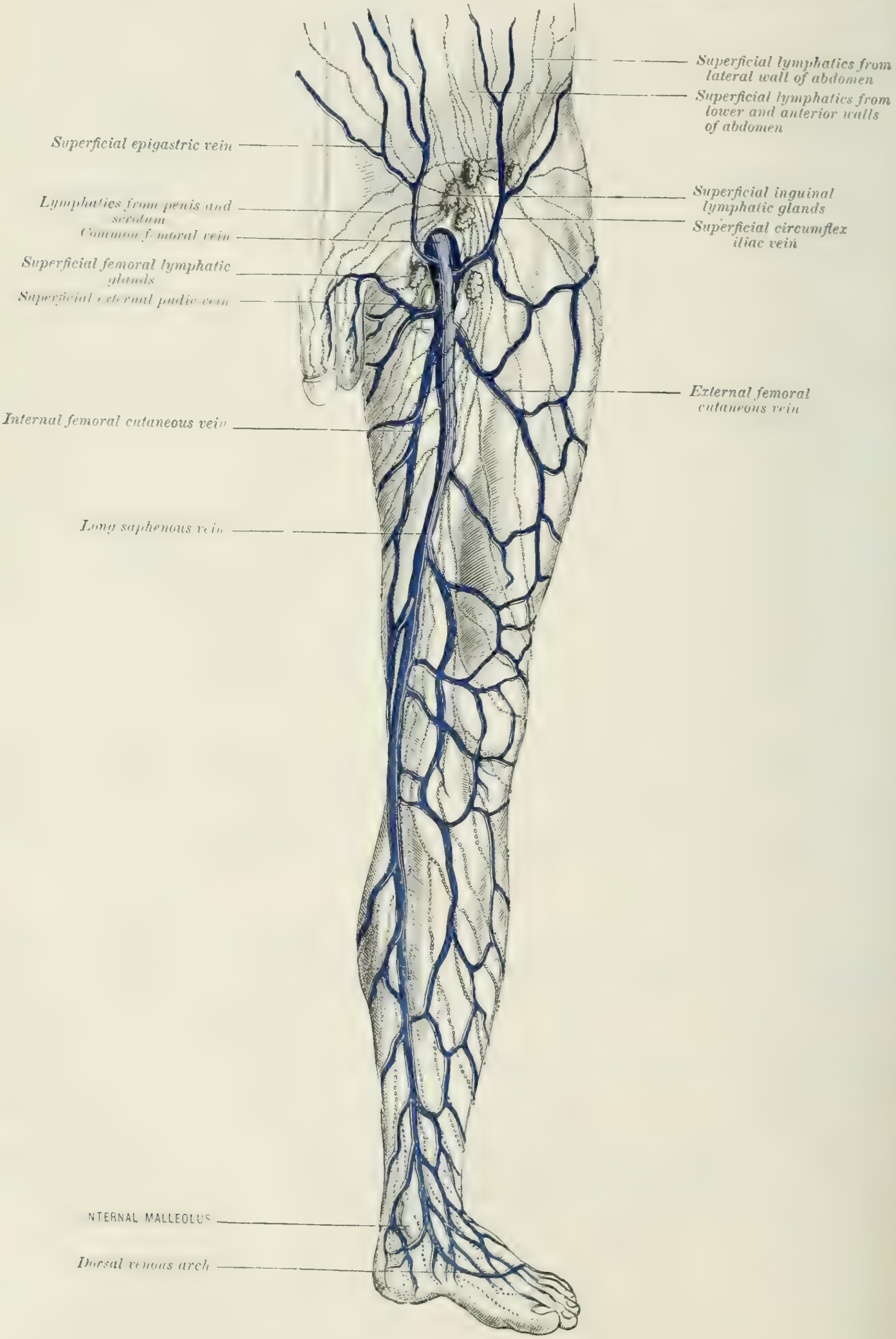
(5) The **lymphatics of the pancreas** consist of a double set, a superficial and a deep. They leave the pancreas along with the vessels derived from the splenic artery, and, joining the lymphatics of the spleen, end in the cœliac glands.

(6) The **lymphatics of the kidneys** ramify, partly on the surface, and partly in the substance of the organ. They unite at the hilum, and run inwards to the central set of lumbar glands, situated immediately in front of the renal vessels. They receive the lymphatics from the **suprarenal bodies** and from the upper part of the ureters.

(7) The **lymphatics of the ureters** end chiefly in the renal lymphatics. Those from the lower part join the posterior vesical set of lymphatics.

(8) The **suprarenal lymphatics** leave the suprarenal bodies with the suprarenal veins, and join for the most part the renal lymphatics in the hilum of the kidneys. A few pass direct into the central lumbar chain of glands.

Fig. 400.—The Superficial Lymphatics of the Left Lower Limb. (Walsham.)


Superficial lymphatics from lateral wall of abdomen
Superficial lymphatics from lower and anterior walls of abdomen
Superficial epigastric vein
Superficial inguinal lymphatic glands
Lymphatics from penis and scrotum
Superficial circumflex iliac vein
Common femoral vein
Superficial femoral lymphatic glands
Superficial external pudic vein
External femoral cutaneous vein
Internal femoral cutaneous vein
Long saphenous vein
NTERNAL MALLEOLUS
Dorsal venous arch

THE LYMPHATICS OF THE LOWER EXTREMITY

The **lymphatics of the lower extremity,** like those of the upper, may be divided into the superficial and the deep. The former run in the subcutaneous tissue with the superficial veins, the latter along the course of the deep arteries. At the groin the superficial end in the deep, which then pass under Poupart's ligament into the abdomen.

I. *THE SUPERFICIAL LYMPHATIC VESSELS AND GLANDS OF THE LOWER EXTREMITY*

The **superficial lymphatic vessels** follow in chief part the long and short saphenous veins. Passing from the toes to a plexus on the dorsum and sole of the foot respectively, they thence run up the leg, forming two chief sets of lymphatic vessels, an inner and an outer. The inner and larger accompanies the long saphenous vein in front of the ankle, behind the inner side of the knee, and then up the inner and front part of the thigh to the inguinal glands. The outer set, beginning on the outer side of the foot, run up the outer side of the leg, some passing round the front of the tibia to end in the inner set below the knee; others passing over the popliteal space to join the inner set higher in the limb; and others, again, perforating the deep fascia along with the short saphenous vein to end in the popliteal glands.

The **lymphatics of the gluteal region** wind, in part round the inner side of the thigh, over the upper portion of the adductors, to join the innermost inguinal glands; and in part over the crest of the ilium to join the outermost inguinal glands. On this account it is not uncommon to find that an abrasion caused by wearing an ill-fitting truss results in an abscess in the inguinal region.

The superficial lymphatic glands.—There are no superficial glands below the inguinal.

The **inguinal glands,** six to twelve in number, are situated in the inguinal region. They may be subdivided into the oblique, or inguinal proper, which are grouped along the course of Poupart's ligament; and the vertical, or femoral, or saphenous, which surround the saphenous opening.

The **oblique** or **inguinal glands proper,** which are situated on a higher level than the vertical set, receive the lymphatics from the integuments of the penis and scrotum, and the skin of the pudenda and lower part of the vagina in the female. They also receive the lymphatics from the integuments of the lower part of the abdomen, and that covering the perinæal and gluteal regions. Their efferent vessels in part pass through the saphenous opening, and in part perforate the deep fascia to end in the deep inguinal and, to some extent, in the lumbar glands. It is these superficial inguinal glands which become enlarged in venereal disease, in chancres and epithelioma of the penis and scrotum, or labia in the female, and in boils or other sources of irritation about the anus, gluteal region, and perinæum.

The **vertical set,** or **saphenous** or **superficial femoral glands,** receive the superficial lymphatics from the lower limb. They are found enlarged in sores on the heel, malignant disease of the skin, etc.

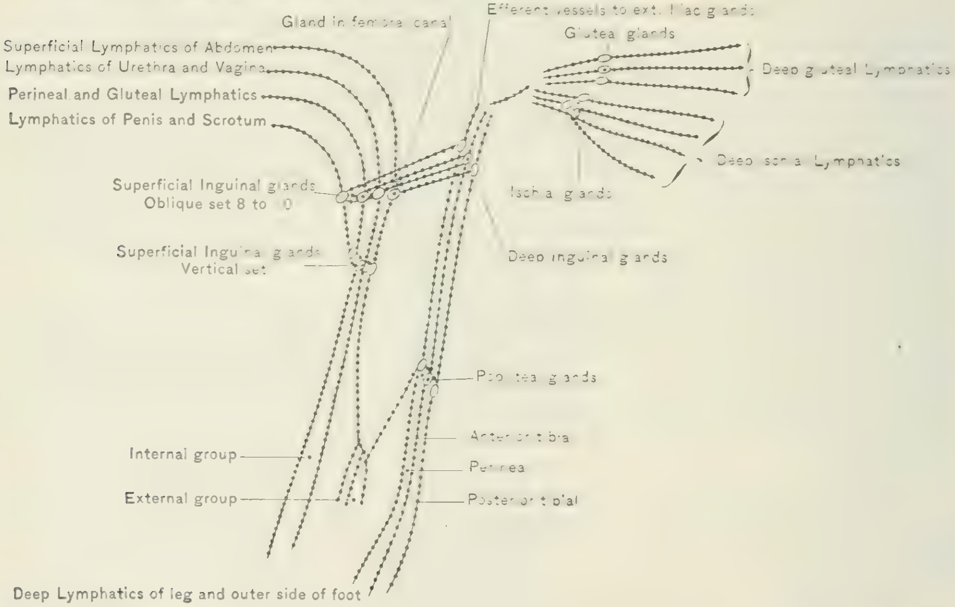
II. *THE DEEP LYMPHATIC VESSELS AND GLANDS OF THE LOWER EXTREMITY*

The **deep lymphatic vessels of the lower limb** follow the course of the deep arteries and veins. Thus they accompany the internal and external plantar arteries in the sole, and the dorsalis pedis artery on the dorsum of the foot. In the leg they are found following the posterior tibial, anterior tibial, and peroneal arteries, and, after passing through the lymphatic glands in the popliteal space, accompany, first, the popliteal, and then the femoral artery up the thigh to the deep inguinal or deep femoral glands. Deep lymphatics also run with the profunda artery. These also join the deep femoral lymphatic glands. Others accompany the gluteal and ischiatic artery, and end in the lymphatic glands of the same name at the great sciatic foramen.

The **deep lymphatic glands of the lower extremity** are met with chiefly in the popliteal space and in the inguinal region. One, or sometimes two, small glands, however, may be found in the upper part of the front of the leg, lying on the interosseous membrane along the course of the anterior tibial artery.

The **popliteal glands** are placed deep in the popliteal space around the popliteal artery and vein, and are about five in number. They receive the deep lymphatics from the leg, and those of the superficial which perforate the deep fascia along with the external saphenous vein. Their efferent vessels accompany the popliteal and the femoral vessels to the deep inguinal or femoral glands.

FIG. 400A.—DIAGRAM OF THE SUPERFICIAL AND DEEP LYMPHATIC VESSELS AND GLANDS OF THE LOWER EXTREMITY, INCLUDING THE SUPERFICIAL LYMPHATICS OF THE EXTERNAL GENITALS AND THE LYMPHATICS OF THE GLUTEAL AND ISCHIAL REGIONS. (After Drawing by Dr. Francis R. Sherwood.)


Gland in femoral canal
Efferent vessels to ext. iliac glands
Gluteal glands
Superficial Lymphatics of Abdomen
Lymphatics of Urethra and Vagina
Deep gluteal Lymphatics
Perineal and Gluteal Lymphatics
Lymphatics of Penis and Scrotum
Deep ischial Lymphatics
Superficial Inguinal glands
Oblique set 8 to 10
Ischial glands
Superficial Inguinal glands
Vertical set
Deep inguinal glands
Popliteal glands
Anterior tibial
Internal group
Peroneal
External group
Posterior tibial
Deep Lymphatics of leg and outer side of foot

The **deep inguinal** or **deep femoral glands** surround the upper part of the femoral vessels. One or more are constantly found in the femoral canal. They receive the deep lymphatics accompanying the femoral artery, and a few of the efferent vessels from the superficial inguinal glands. Their efferent vessels pass, in part along the course of the femoral vessels, and in part through the femoral ring to join the glands along the course of the external iliac artery.

SECTION V

THE NERVOUS SYSTEM

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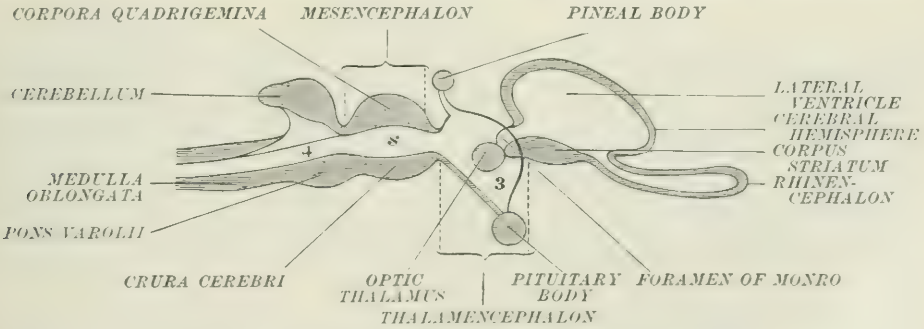
Revised for Second Edition by ARTHUR ROBINSON, M.D., M.R.C.S.England

LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

NEUROLOGY

NEUROLOGY is that branch of Anatomy which deals with the nervous system. It treats of the brain and spinal cord, constituting the **cerebro-spinal axis** or **central nervous system**; the cranial and spinal nerves, or **peripheral nervous system**, and the **sympathetic system**, which is intimately connected with the two former and closely associated with the vessels, viscera, and glands. The study of the nervous system (of the brain in particular) is greatly facilitated by a knowledge of its mode of development and by Comparative Anatomy. It is not our purpose to enter into these subjects here; but an examination of the two diagrams (figs. 401 and 402), which are based upon Embryology and Comparative Anatomy, will familiarise the student with the plan upon which the brain is laid down, and form a key to the complicated structure of the adult human brain.

Fig. 401.—Diagrammatic Sagittal Section of a Vertebrate Brain. (After Huxley.)


CORPORA QUADRIGEMINA
MESENCEPHALON
PINEAL BODY
CEREBELLUM
LATERAL VENTRICLE
CEREBRAL HEMISPHERE
CORPUS STRIATUM
RHINENCEPHALON
MEDULLA OBLONGATA
PONS VAROLII
4
s
3
CRURA CEREBRI
OPTIC THALAMUS
PITUITARY BODY
FORAMEN OF MONRO
THALAMENCEPHALON

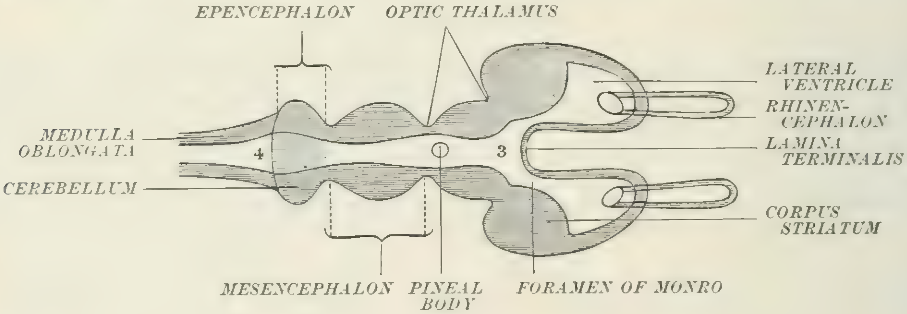
4, fourth ventricle; s, aqueduct of Sylvius; 3, third ventricle.

At an early period of embryonic life the cerebro-spinal axis consists simply of a thin walled tube, the **neural tube**, which becomes enlarged at the cephalic end of the body. Constrictions appear on this enlarged cephalic end, dividing it into three vesicles, an **anterior,** a **middle,** and a **posterior.** The ventricles of the brain are afterwards developed from these three cerebral vesicles, and the remainder of the neural tube forms the central canal of the spinal cord. The substance of the brain and cord is formed by thickenings of the wall of this neural tube. The terminal or anterior cerebral vesicle becomes divided into an anterior and a posterior division; the latter persists as the **third ventricle,** which, with the parts around it, constitutes the **thalamencephalon.** The anterior division is afterwards differentiated into the **cerebral hemispheres** or **prosencephalon.** It becomes at first indented in the middle line, and then completely bilobed. In this way two symmetrical cavities, the **right** and **left lateral ventricles,** are formed.

The anterior part of the wall of the cerebral vesicle between the two hemispheres, thus mapped out, is called the **lamina terminalis.** The lamina terminalis is carried backwards so as to bound the third ventricle in front, and the aperture of communication (**foramen commune anterius**), connecting the third with the lateral ventricles, becomes narrowed. The cavity of the middle cerebral vesicle becomes the **aqueduct of Sylvius,** and the parts developed around it constitute the mid-brain or **mesencephalon.** The cavity of the posterior cerebral vesicle becomes the **fourth ventricle,** and its walls are differentiated into the **cerebellum** and **pons Varolii** (**epencephalon**), and into the **medulla oblongata** (**metencephalon**).

The walls of the lateral ventricles become greatly thickened and form the cerebral hemispheres, constituting the greater part of the mass of the brain. They grow backwards from the position represented in the diagram (fig. 401), and cover the mid- and hind-brain. In front of the lamina terminalis the walls of the lateral ventricles remain thin, and approximate so as to enclose a narrow space, the **fifth ventricle.** Thus the fifth ventricle differs entirely in its nature from the other ventricles of the brain: it is a separated portion of the interhemispheric or great longitudinal fissure, and has nothing to do with the true ventricular cavities; according to Testut it is lined by a rudimentary layer of pia mater. Later on, a great transverse commissure (**corpus callosum**), which passes from one hemisphere to the other, is developed. It commences in front of the fifth ventricle in the secondarily fused portions of the cerebral walls, and afterwards extends backwards as the hemispheres grow over the mesencephalon.

Fig. 402.—Diagrammatic Horizontal Section of a Vertebrate Brain. (After Huxley.)



The oldest portion of the cerebral hemisphere, both in the series of vertebrates and in the development of the individual, is the island of Reil with the grey masses which lie subjacent to it (nucleus caudatus and nucleus lenticularis of the corpus striatum). These structures constitute a **central portion** (**Stammtheil** of Schwalbe) which is almost completely invested by the remaining larger part of the hemisphere. The latter forms the less massive part of the wall of the lateral ventricle, and may be called the **mantle-wall** (**Manteltheil** of Schwalbe).

The ventricular cavities of the brain and the central canal of the spinal cord are lined by a layer of epithelial cells, immediately outside which is a stratum of neuroglia, free from nerve-cells, which is called **ependyma.** The ependyma around the central canal of the cord is often termed **substantia gelatinosa centralis.**

Neuroglia is the name given to the peculiar interstitial tissue of the brain and cord. It is continuous with processes of pia mater which dip in from the surface.

Nerve-fibres are processes or outgrowths of the nerve-cells of the central nervous system, from which they pass to be distributed to every part of the body. They are classed by physiologists into efferent and afferent fibres. Efferent or centrifugal nerve-fibres convey impulses from the nerve-centres; they comprise motor nerves to muscles, secreto-motor nerves to glands and vaso-motor nerves. Afferent or centripetal nerves convey impulses towards the nerve-centres; they comprise sensory nerves and other nerves conveying impulses, which under ordinary circumstances do not produce conscious sensations. Nerve-fibres run for the greater part of their course in compact bundles of various sizes, and these bundles are called **nerves** in the most general use of the term. Nerves are usually mixed (i.e. contain both efferent and afferent fibres). Most nerves are of a whitish colour owing to a medullary sheath which invests the essential parts (axis-cylinders) of the individual fibres. Others (chiefly visceral nerves) are of a pearly-grey colour owing to the absence of the medullary sheath in the majority of the fibres which make up the nerve.

The fibres of sensory nerves are outgrowths from nerve-cells contained in ganglia, such as the Gasserian ganglion and the ganglia on the posterior roots of the spinal nerves. These ganglia, although appearing to belong to the peripheral nervous system in the adult, were (in early embryonic life) in continuity with the general epiblast of the neural canal.

Certain terms which are in frequent use, such as **coronal, sagittal,** and **horizontal,** may be defined here. A **coronal section** is a vertical section passing through or parallel to the coronal suture, in other words, a transverse vertical section. A **sagittal section** is a vertical section taken at right angles to a coronal section—an antero-posterior vertical section. A **horizontal section** is a section taken at right angles to the perpendicular axis of the body. Structures which lie in the planes of these sections are sometimes spoken of as coronally placed, sagittally directed, etc.

THE MENINGES

The brain and spinal cord are invested by three membranes, termed the **meninges,** which afford protection and support to the delicate nervous structures and also furnish a convenient medium in which the blood-vessels can ramify. The outer of these is thick and tough, and is termed the **dura mater.** The intermediate and inner membranes (**arachnoid** and **pia mater**) are thin and delicate. These membranes present differences in the regions of the brain and spinal cord respectively. The membranes of the brain will be first considered, and the differences met with in relation to the spinal cord will be dealt with in the description of that region.

Dissection.—The first step in the examination of the meninges is the removal of the brain. The calvaria should be removed as follows:—The bone having been laid bare, a string should be tied round the skull passing from about an inch and a quarter above the external occipital protuberance behind, to an inch above the orbital arches in front. The outer table of the skull should then be sawn through and the inner table afterwards cracked with the mallet and chisel. A slight wrench will now disengage the calvaria. After noticing the Pacchionian bodies and the meningeal arteries, the student will do well to examine the superior longitudinal sinus by laying it open. He should next cut through the dura mater in an antero-posterior direction on each side of the sinus, and then make incisions directed transversely outwards from the central points of the two previous incisions as far as the cut margin of the bone. The four triangular flaps thus mapped out should be turned downwards, and by gently drawing one of the hemispheres aside, the falx cerebri may be seen *in situ* within the great longitudinal fissure, and the veins entering the superior longitudinal sinus may be noted. The falx should then be divided close to its attachment to the crista galli and thrown backwards. The head should next be inclined backwards and the frontal lobes of the brain gently raised. The following structures will then come into view, viz. the olfactory bulbs, the second, third, and fourth nerves, the infundibulum, and the internal carotid arteries. The olfactory bulbs will come away with the brain, but the other structures will require to be divided with scissors, as the nerves are frequently torn away from their connections by using a scalpel for this purpose. The head should next be gently inclined towards the right side, and the tentorium divided close to its attachment to the bone. The sixth, seventh, and eighth nerves should be cut at the same time. This dissection should be repeated on the opposite side. The head should then be tilted backwards, and the remaining cranial nerves, the vertebral arteries, and the commencement of the spinal cord cut through. The latter should be divided as low down as it can be reached with the scalpel. The brain can now be removed from the cranial cavity, the veins of Galen being ruptured by this process.

The **DURA MATER** is a tough fibrous membrane of a bluish-white colour presenting externally a rough appearance, but internally smooth and shining. It performs the double function of an endosteum to the interior of the skull and of affording support and protection to the brain. In correspondence with this double function it may be regarded as consisting of two layers, an **outer** or **periosteal lamina,** and an **inner** or **supporting lamina.** These layers are inseparable for the greater part of their extent, but along certain lines the inner lamina leaves the periosteal lamina and forms shelf-like projections (of which the falx cerebri and the tentorium cerebelli are examples) into the cranial cavity. Along the lines where these layers divaricate spaces occur which form cranial sinuses. A **cranial sinus** may be defined as a space formed by the cleavage of the dura mater, lined by a prolongation of the lining membrane of a vein and conveying venous blood. Some of the sinuses are placed between the periosteal and supporting layers of the dura mater—the lateral sinus is a good example of this class. Others (as the straight sinus) are bounded wholly by the inner or supporting layer.

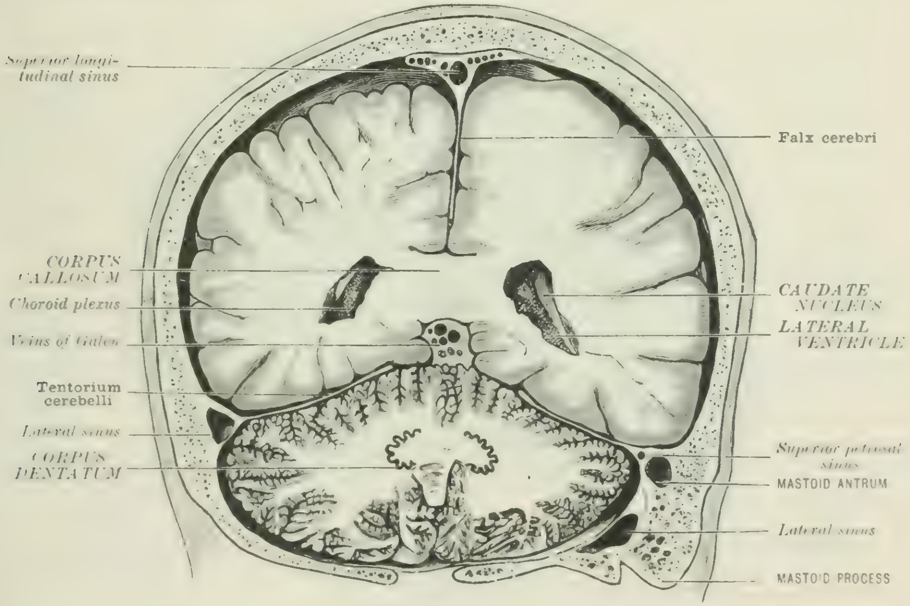
The **cranial sinuses** form two principal systems, which, however, communicate with each other. The following is a list of the sinuses which unite to form the larger of these two systems:—**superior longitudinal, inferior longitudinal, straight, occipital, superior petrosal.** These form a system which converges at the **torcular Herophili,** a dilated blood-space situated on the right side (rarely on the left) of the internal occipital protuberance. The blood from the torcular is drained away by the **lateral sinuses** (more particularly by the right sinus), which also receive blood from the cavernous sinuses by the superior petrosal sinuses, and it leaves the cranium through the posterior compartment of the jugular foramen. The straight sinus usually passes into the left lateral sinus. The smaller system comprises the **spheno-parietal, cavernous, circular, transverse,** and **inferior petrosal sinuses.** The blood from this system passes into the internal jugular vein by the inferior petrosal sinus through the anterior compartment of the jugular foramen.

Emissary veins.—These veins are possibly extracranial tributaries of the cranial sinuses under normal conditions, but, in cases of engorgement of the sinuses, permit the flow of blood in the opposite direction, and become, in accordance with their name, emissary. The **mastoid emissary** is the most important of these veins; it passes through the mastoid foramen to enter the lateral sinus, and explains the value of applying leeches behind the ears in cases of cerebral congestion. Three small **emissaries** enter the superior longitudinal sinus, one of these passes through the foramen cæcum; the others traverse the parietal foramina. An additional **vein** occasionally passes to the torcular Herophili through a foramen in the occipital bone near the external occipital protuberance. **Emissary veins** pass through the foramen ovale and foramen of Vesalius, and place the cavernous sinus in communication with the pterygoid venous plexus; others traverse the cartilage which occupies the foramen lacerum medium. **Small veins** enter the lateral sinuses through the anterior and posterior condyloid foramina. A minute **venous plexus,** which accompanies the internal carotid artery through the carotid canal, establishes a communication between the cavernous sinus and the internal jugular vein. (Rektorzik.)

The dura mater of the brain is continuous through the foramen magnum with the dura mater of the cord. It is also continuous, through the various foramina in the cranium, with the external periosteum of the skull. This is most easily observed at the sphenoidal fissure, but may be made out with ordinary care at any of the other foramina. It sends a strong prolongation through the optic foramen which splits into two layers, one of which forms the sheath of the optic nerve, and the other is continued into the periosteum of the orbit. On account of the number of foramina at the base of the skull, it follows that the dura mater is more firmly connected to the bone here than at the roof and sides. In the region of the basilar process of the occipital bone, the dura mater splits into supporting and periosteal layers. The supporting layer passes through the foramen magnum to become continuous with the dura mater of the spinal cord. The periosteal layer clothes the bone and is thickened into a ligamentous band, the occipito-cervical or cervicobasilar ligament (page 188), which passes through the foramen magnum to join the posterior common ligament of the vertebræ and to gain attachment to the body of the axis. Thus a connection is established between the dura mater and the periosteum of the vertebræ. At the back and sides of the foramen magnum the dura mater does not split into periosteal and supporting layers until it reaches the margin of that opening, where its layers divaricate, the one to become continuous with the external periosteum of the skull, the other to be continued into the spinal dura mater. In the middle fossa of the skull there is a separation of the periosteal and supporting layers to form the cavernous sinus; on the inner side of this the supporting layer is moulded round the pituitary body and then folds on itself to form the **diaphragma sellæ** which roofs in the pituitary fossa. External to the cavernous sinus the two layers remain separate for some distance, forming a space (**Meckel's space**), which encloses the Gasserian ganglion. The outer surface of the dura mater is covered with a number of arteries, which ramify between it and the inner table of the skull. These vessels break up into small twigs which penetrate the bone. The term **meningeal**, applied to the arteries in question, is somewhat misleading, inasmuch as they do not supply any of the meninges, except the dura mater, being chiefly destined for the nutrition of the cranial bones. These small vessels, together with a number of fibrous retinacula, are torn across when the dura mater is forcibly detached from the bone, and give rise to the rough appearance which is presented by its outer surface. An examination under water will, however, reveal smooth spots interspersed among the bundles of ruptured vessels; these are subperiosteal lymph-spaces.

FIG. 403.—CORONAL SECTION OF THE HEAD PASSING THROUGH THE MASTOID PROCESS.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)



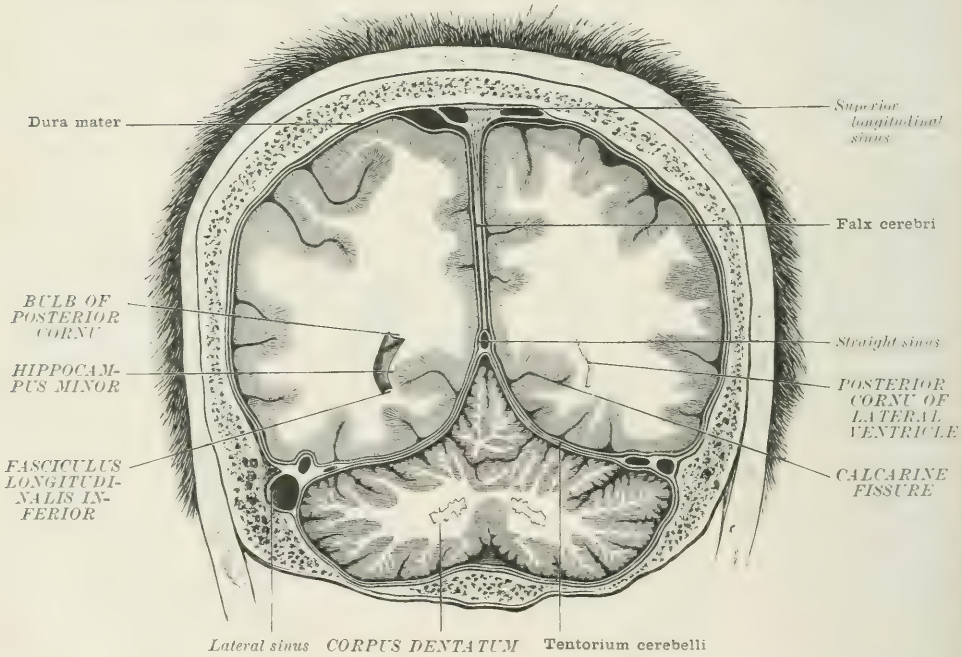
Meningeal arteries.—The **middle** or **great meningeal artery**, which enters the middle cranial fossa through the foramen spinosum, supplies the dura mater which lines the vault of the cranium. In addition to this there are meningeal arteries, mostly of small size, which are limited in their distribution to the base of the cranium. In the anterior cranial fossa there are **anterior meningeal branches** of the anterior and posterior ethmoidal arteries, which enter the cranium through the anterior and posterior internal orbital canals; also twigs from the middle meningeal which usually pierce the great wing of the sphenoid near the outer angle of the sphenoidal fissure. In the middle cranial fossa the following arteries are met with: a **branch** of the ascending pharyngeal which perforates the cartilage which occupies the foramen lacerum medium; the **meningea parva** which enters the cranium through the foramen ovale; the **meningeal branch** of the internal carotid, and **twigs** from the middle meningeal. In the posterior cranial fossa, two **meningeal branches**, derived from the occipital and ascending pharyngeal, enter through the posterior compartment of the jugular foramen, another **twig** from the occipital passes through the mastoid foramen, and a twig from the ascending pharyngeal makes its way through the anterior condyloid foramen. A **meningeal branch** of the vertebral is given off from that artery, in the interval between the occipital bone and the posterior arch of the atlas, and enters the skull through the foramen magnum.

A branch of the occipital artery (**ramus parietalis**, Cruveilhier) occasionally passes through the parietal foramen to the dura mater lining the calvaria.

The following are the infoldings formed by the inner or supporting layer of the dura mater, taken in their order of magnitude: the **falx cerebri**, the **tentorium cerebelli**, the **falx cerebelli**, and the **diaphragma sellæ**. There are also two smaller paired folds; viz. the folds which project from the lesser wings of the sphenoid bone into the Sylvian fissures of the brain, and the crescentic folds which are placed over the optic nerves at the upper margin of the optic foramina.

FIG. 404.—CORONAL SECTION OF THE HEAD PASSING THROUGH THE POSTERIOR HORNS OF THE LATERAL VENTRICLES.

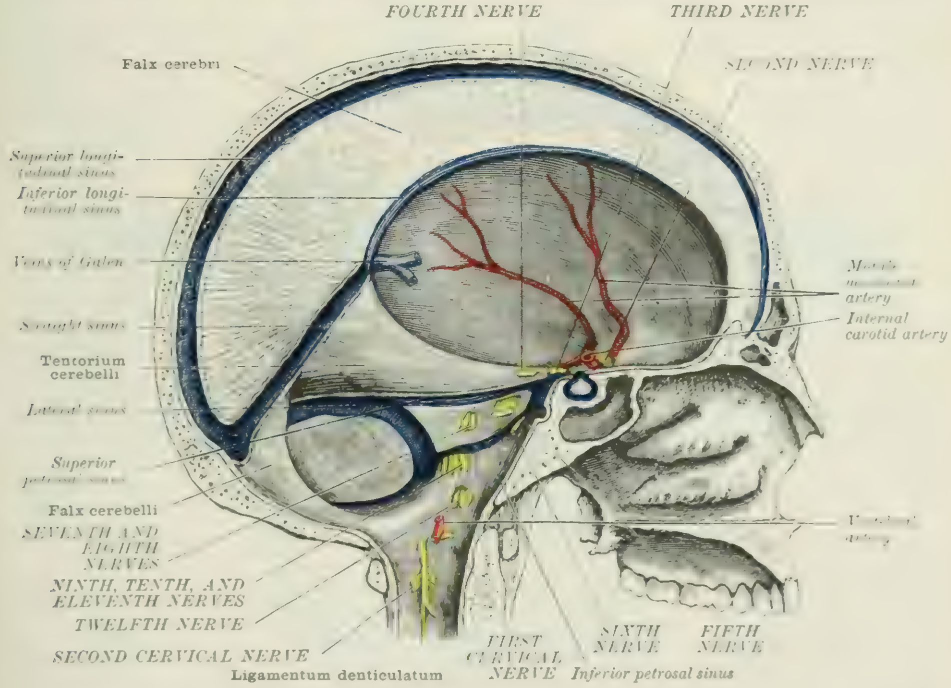
(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)



The **Falx Cerebri** is a large sickle-shaped process, deeper behind than in front, which is placed in the great longitudinal fissure of the brain. It is attached by its base to the tentorium cerebelli, in the middle line, and maintains by its tension the vaulted character of the latter. The straight sinus follows this line of attachment. Its apex is firmly fixed to the crista galli of the ethmoid, and has also an attachment to the ethmoidal spine of the sphenoid bone. Its convex or upper margin corresponds to the superior longitudinal sinus, and is attached to the periosteal layer opposite to the edges of the groove for that sinus in the frontal, the two parietal, and the occipital bones. The inferior longitudinal sinus courses along its concave or free margin. This margin closely approaches the corpus callosum behind, but is separated from it by a considerable interval in front.

The **Tentorium Cerebelli** occupies the interval between the cerebrum and cerebellum. It presents for examination an upper surface, a lower surface, a free or concave border, and an attached or convex border. The **upper surface** is in contact with the occipital and temporal lobes of the cerebrum, and is strongly convex upwards, forming a roof-like structure, to the ridge of which the base of the falx cerebri is attached. This ridge also slopes upwards and forwards, so that its highest point is situated at the free border. The **under surface** is in apposition to the cerebellum. The **free border** bounds an opening usually described as oval, but which is more properly triangular with curved sides, the apex of the triangle being turned backwards, and corresponding to the point where the veins of Galen enter the straight sinus. This opening transmits the crura cerebri and the superior peduncles of the cerebellum, these parts forming an isthmus connecting the masses of brain substance above and below the tentorium; the basilar artery and the third pair of cranial nerves also pass upwards through it. Followed forwards, the free border is seen to be attached to the anterior clinoid processes of the sphenoid bone. The **attached border** follows the lateral sinus along the occipital and parietal bones, and then corresponds to the superior petrosal sinus along the superior border of the petrous portion of the temporal, and finally dips under the free border, to be attached to the posterior clinoid process of the sphenoid bone.

FIG. 405.—THE CRANIUM OPENED TO SHOW THE FALX CEREBRI, THE TENTORIUM CEREBELLI, AND THE PLACES WHERE THE CRANIAL NERVES PIERCE THE DURA MATER. (Sappey.)


FOURTH NERVE
THIRD NERVE
Falx cerebri
SECOND NERVE
Superior longitudinal sinus
Inferior longitudinal sinus
Veins of Galen
Middle meningeal artery
Internal carotid artery
Straight sinus
Tentorium cerebelli
Lateral sinus
Superior petrosal sinus
Falx cerebelli
Vertebral artery
SEVENTH AND EIGHTH NERVES
NINTH, TENTH, AND ELEVENTH NERVES
TWELFTH NERVE
SECOND CERVICAL NERVE
Ligamentum denticulatum
FIRST CERVICAL NERVE
SIXTH NERVE
FIFTH NERVE
Inferior petrosal sinus

The **Falx Cerebelli** is a small prominent fold, which is placed between the cerebellar hemispheres. Its attached border corresponds to the occipital sinus along the internal occipital crest. Above this it is attached for a short distance to the under surface of the tentorium. Its free border looks upwards and forwards.

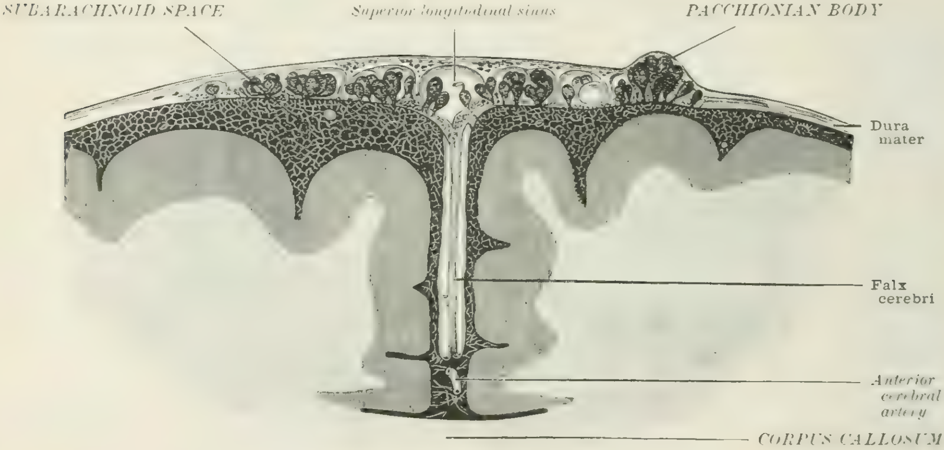
The **diaphragma sellæ** is a small, annular, shelf-like fold of the dura mater which roofs in the pituitary fossa, leaving a small aperture in the centre, which transmits the infundibulum.

The **subdural space** is a narrow lymph-space between the dura mater and the arachnoid. It is occupied by a small portion of the cerebro-spinal fluid, the greater part of which, however, is lodged in the meshes of the subarachnoid tissue, and in the ventricles of the brain (page 678). This space separates the arachnoid from the dura mater, except where it is crossed by the veins of the brain passing to the cranial sinuses, by the Pacchionian bodies, and by the cranial nerves at their points of exit from the skull.

The **ARACHNOID** is a thin delicate membrane, which presents a well-defined limiting surface towards the dura mater, but on its deep or pia-matral surface passes insensibly into the subarachnoid tissue. The arachnoid does not dip into the fissures of the cerebrum and cerebellum, with the exception of those fissures which contain processes of dura mater. Thus it is carried into the great longitudinal fissure for a depth corresponding to the falx cerebri, and it passes for a short distance into the fissure of Sylvius around the fold of dura mater which projects from the lesser wing of the sphenoid.

On each side of the superior longitudinal sinus groups of small lobulated bodies, the so-called **Pacchionian glands,** project from the surface of the arachnoid; these are enlargements of the normal villi of that membrane which perforate the dura mater and cause absorption of the bone in their vicinity. Most of these bodies are lodged in irregular pits in the calvaria; others project into the superior longitudinal sinus. They may also occur in other situations.

Fig. 406.—Coronal Section through the Great Longitudinal Fissure, showing the Meninges. (Key and Retzius.)



The **subarachnoid tissue** consists of very fine trabeculæ, clothed with endothelial cells, which pass from the arachnoid to the pia mater. Thus, a **subarachnoid space,** in the proper sense of the word, does not exist; it is convenient, however, to retain the term to designate the region which is occupied by the subarachnoid tissue, and to speak of the accumulations of this tissue which are formed in regions where the distance between the arachnoid and pia mater is increased as **subarachnoid spaces.** It should be understood, however, that in these larger spaces the subarachnoid tissue is less abundant and the meshes are larger than in the regions where the arachnoid and the pia mater are more approximated.

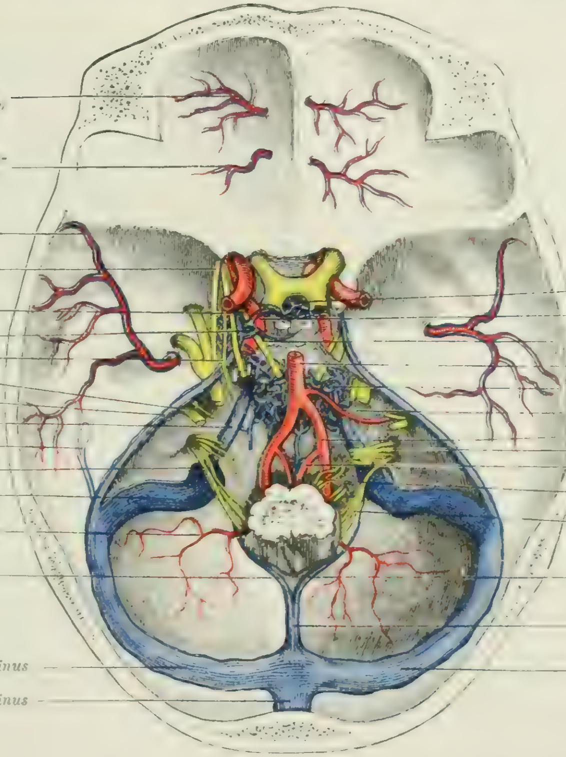
The largest of these spaces is the **cisterna magna,** which is a continuation of the posterior subarachnoid space of the spinal cord. This space appears triangular in sagittal section. It is bounded in front by the layer of pia mater (**tela choroidea inferior,** page 718) which closes in the lower part of the roof of the fourth ventricle, and above by the inferior vermiform process of the cerebellum. It extends laterally as far as the outer margins of the tonsillar lobes. It communicates with the fourth ventricle by means of three small openings; the principal of these (**foramen of Majendie**) is in the middle line of the tela choroidea inferior immediately above the obex (page 718). The two others (foramina of Key and

Retzius) are at the extremities of the recessus laterales of the fourth ventricle, behind the upper roots of the glosso-pharyngeal nerves. Another large space, the **cisterna pontis,** is continued from the anterior subarachnoid space of the cord, and extends forwards as far as the commencement of the great longitudinal fissure, and laterally to the inner margins of the temporo-sphenoidal lobes. The basilar artery and the circle of Willis are placed in this space. The cisterna pontis communicates freely around the medulla oblongata with the cisterna magna—thus the medulla is encircled by a wide subarachnoid space.

A large space is also to be found between the lower edge of the falx cerebri (where the arachnoid passes across from one cerebral hemisphere to the other) and the upper surface of the corpus callosum. This space contains the trunks and larger branches of the anterior cerebral arteries. Another considerable space exists in the fissure of Sylvius, and in this the middle cerebral artery ramifies. Thus, with the exception of the cisterna magna, all these spaces serve for the accommodation of large arteries. There is also a space between the corpora quadrigemina and the anterior extremity of the superior vermiform process of the cerebellum, and through this the veins of Galen pass to terminate in the straight sinus.

FIG. 407.—CRANIAL NERVES IN THE BASE OF THE SKULL.

(On the left side the dura mater has been removed in the middle fossa.)


Meningeal branch of anterior ethmoidal artery
Meningeal branch of posterior ethmoidal artery
Middle meningeal artery
OPHTHALMIC DIVISION OF FIFTH NERVE
THIRD NERVE
Cavernous sinus
FOURTH NERVE
AUDITORY AND FACIAL NERVES
Superior petrosal sinus
Inferior petrosal sinus
Petro-squamous sinus
SPINAL ACCESSORY NERVE
Sigmoid portion of lateral sinus
Posterior meningeal branch of vertebral artery
Left marginal sinus
Left lateral sinus
Superior longitudinal sinus
Circular sinus
Carotid artery
SIXTH NERVE
Basilar artery
Basilar plexus of veins
Auditory artery
Vertebral artery
GLOSSO-PHARYNGEAL AND PNEUMOGASTRIC NERVES
HYPOGLOSSAL NERVE
SPINAL ACCESSORY NERVE
Right marginal sinus
Occipital sinus
Right lateral sinus

The **PIA MATER** is a delicate vascular membrane which closely invests the nervous substance. It follows accurately the contour of the surface of the brain, dipping into all the fissures of the cerebrum and cerebellum—in the smaller sulci of the latter, however, a double layer cannot be distinctly made out. Processes or folds of this membrane project into some of the ventricles of the brain, and are separated from the ventricular cavities only by a layer of epithelium. These folds form the velum interpositum and choroid plexuses, which will be described with the anatomy of the ventricles. The blood-vessels, which divide freely in the subarachnoid tissue, subdivide into the pia mater, forming by their inosculations fine networks from which innumerable minute vessels proceed to penetrate the nervous substance.

LYMPHATICS OF THE BRAIN AND SPINAL CORD

The lymphatics of the brain and spinal cord are peculiar, inasmuch as they open into the subarachnoid space, and are only indirectly connected with the general lymphatic and venous systems. The communications with the venous system are effected by the Pacchionian bodies. The lymphatics of the peripheral nerves are in the form of tubular spaces placed between the lamellæ of the perineural sheaths. These tubular channels open into the subdural and subarachnoid spaces.

The **subdural space** is a very narrow interval between the dura mater and arachnoid (page 675). It normally contains only sufficient fluid to moisten its surfaces. It is in communication with the lymphatics of the neck and also of the back and loins. It also communicates with the perineural spaces around the nerves, and with the lymph spaces which surround the olfactory, optic, and auditory nerves. It sends prolongations around the Pacchionian bodies. It does not communicate with the subarachnoid space.

The **subarachnoid space** contains the greater part of the cerebro-spinal fluid, the fluid occupying the meshes of the subarachnoid tissue. The lymphatics of the brain and cord and also the perineural spaces of the nerves open into this space. It is also in communication with the ventricular system of the brain by means of the foramen of Majendie and the foramina of Key and Retzius. Slit-like communications between the subarachnoid space and the descending horn of the lateral ventricle have also been described (Merkel and Mierzejewsky). It also communicates with the perilymph spaces of the internal ear and with the lymphatics of the mucous membrane of the nose. It sends prolongations around the optic and auditory nerves.

The lymphatic vessels of the brain and cord surround the arteries, and are hence called perivascular lymphatics. As each artery dips into the nervous substance it carries with it a tubular process of the pia mater. This tubular process is lined by endothelial cells and a similar layer covers the coat of the artery. In this manner the lymph space is bounded. The perivascular lymphatic follows the artery as far as its capillary ramifications.

There is a lymph-space between the two layers of the spinal pia mater. Lymph-spaces between the outer and middle coats of the cerebral arteries (Virchow-Robin space) and others around the individual nerve-cells of the brain have been described, but these are very generally believed to be artificial, being due to shrinking from the action of reagents. According to Obersteiner, however, the existence of the pericellular spaces 'is proved by the presence within them of lymphatic cells.' The so-called **epicerebral** and **epispinal spaces**, situated between the deep surface of the pia mater and the nervous substance, are also artificial.

Structure of a Pacchionian body.—A Pacchionian body consists of (*a*) a central core of subarachnoid tissue which is joined to the general subarachnoid tissue by a comparatively narrow stalk. This is limited by (*b*) a layer of arachnoid; around which is (*c*) a prolongation of the subdural space. Bounding this space is (*d*) a very thin layer of membrane derived from the inner layer of the dura mater. It has been shown experimentally that injections thrown into the subarachnoid space permeate the Pacchionian bodies and pass into the venous sinuses into which these bodies project. In this course the injection distends the subdural space of the Pacchionian body, but does not enter the general subdural space. It should be mentioned, however, that anatomical pores by which the injection could pass do not exist. It is probable from these experiments that an outlet for the cerebro-spinal fluid is provided by the Pacchionian bodies.

Cerebro-spinal fluid.—The cerebro-spinal fluid occupies the subdural and subarachnoid spaces of the brain and cord and also the ventricular cavities of the brain. The average quantity is about two ounces (Landois and Stirling). Its specific gravity is about 1010. It is of a very pale yellow colour, and presents many of the characters of ordinary lymph, but differs from lymph in not being coagulable, as it does not contain either fibrin factors or fibrin ferment. It contains a substance which acts on Fehling's solution like dextrose, but which is not a sugar (Foster).

The cerebro-spinal fluid is derived in part from the lymphatic vessels which open into the subarachnoid and subdural spaces, but is also believed to be secreted by the epithelial cells which cover the choroid plexuses. These cells are cubical in form, and resemble secreting cells; a process of the choroid plexus covered by these cells has been aptly compared by Foster to 'an everted alveolus of a secreting gland, with the epithelium outside and the blood-vessels within.'

THE ENCEPHALON

The **encephalon,** or **brain,** is the portion of the cerebro-spinal axis which is lodged within the cranial cavity and constitutes (by weight) about 98 per cent. of the whole. It consists of the cerebrum, the cerebellum, the pons Varolii, and the medulla oblongata. The medulla is continuous with the spinal cord at the decussation of the pyramids. The encephalon, taken as a whole, is ellipsoidal or ovoidal in form, presenting above a tolerably even convexity formed by the cerebral hemispheres, but below a more irregular surface corresponding to the fossae in the base of the skull. The **cerebrum** comprises the cerebral hemispheres containing the lateral ventricles (**prosencephalon**), the optic thalami with the third ventricle between them (**thalamencephalon**), and the **mesencephalon.** It occupies the upper compartment of the cranial cavity, resting on a floor formed by the anterior and middle cranial fossae and the tentorium cerebelli. The **cerebellum** occupies the posterior cranial fossa, and is placed behind the fourth ventricle. It is connected by three pairs of **peduncles** or **crura** to the cerebrum, pons, and the medulla respectively. The fourth ventricle is bounded in front by the pons and medulla.

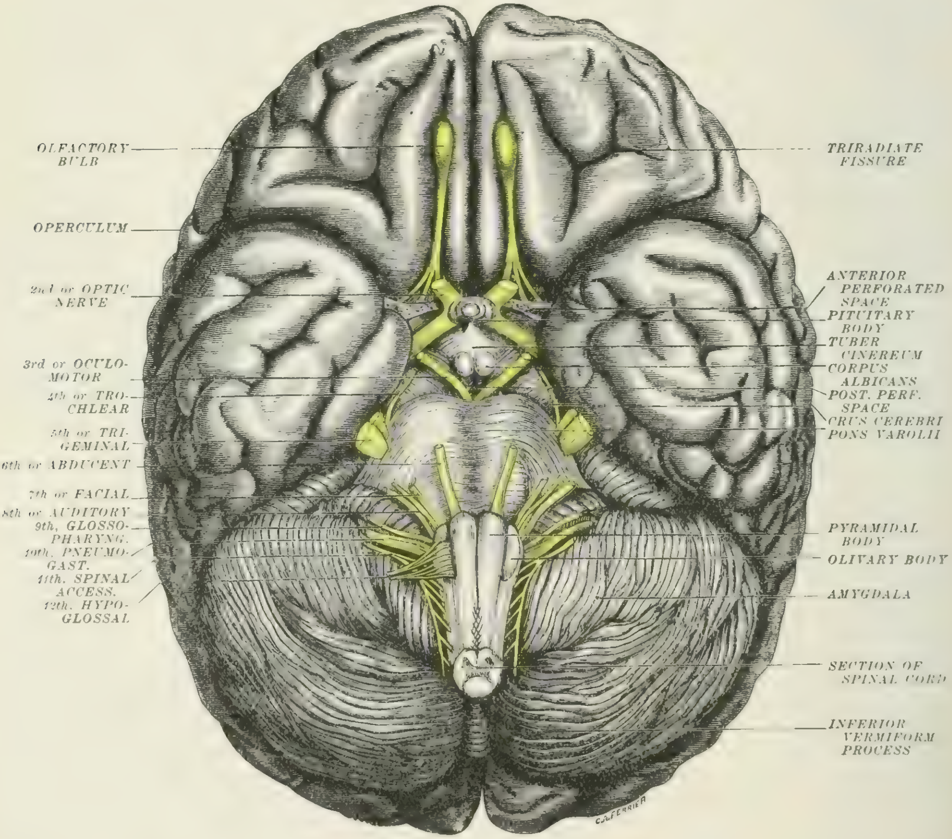
In every part of the encephalon two distinct kinds of nervous substance are to be met with, termed grey and white matter. The **grey matter** is chiefly disposed upon the surface, as in the convolutions of the cerebrum and cerebellum; but it is also met with in detached or partially detached masses or nuclei, such as the corpora striata and optic thalami in the cerebrum, the nuclei of the medulla and pons, and the corpus dentatum of the cerebellum. It is composed of groups of ganglion cells, which possess the power of originating nervous impulses; or of receiving impulses produced by the action of external stimuli on the end-organs of nerves; or of modifying and redirecting such impulses. The **white matter** occurs in the greatest quantity in the central parts of the cerebral hemispheres. It is composed of medullated nerve-fibres, which conduct the impulses to and from the ganglion cells in the grey matter. Both grey and white matter are supported by a delicate interstitial tissue termed neuroglia.

Base of the Brain

Dissection.—The student is recommended to commence the dissection of the brain by a general examination of the structures forming the base of that organ. He should carefully remove the remains of the membranes from the base, and after studying that region should proceed in a similar manner to remove the membranes from the superior and lateral surfaces of the cerebral hemispheres.

The base of the brain presents for examination the inferior surfaces of the frontal and temporo-sphenoidal lobes of the cerebrum; the structures contained within and adjacent to the interpeduncular space; the anterior surfaces of the pons Varolii and medulla oblongata, the inferior surfaces of the lateral hemispheres of the cerebellum; and the superficial origins of the cranial nerves. In front, the orbital surfaces of the frontal lobes are seen separated from one another by the great longitudinal fissure, and indented by the triradiate and olfactory sulci, the latter occupied by the olfactory tract and bulb. Behind and somewhat laterally the frontal lobes are marked off from the temporal lobes by the fissure of Sylvius, near the commencement of which is the anterior perforated space. This space is of a grey colour, and is formed by a part of the lenticular nucleus of the corpus striatum, which comes to the surface at the base of the brain. The perforations are caused by small arteries which proceed from the middle cerebral artery to the corpus striatum. Each space is bounded internally by one of the peduncles of the corpus callosum. The latter are white bands which pass from the corpus callosum to the commencement of the fissure of Sylvius. Between the temporo-sphenoidal lobes is a large recess, which is bounded in front by the frontal lobes, and behind by the pons Varolii; within this is the remarkable arterial anastomosis known as the circle of Willis, the crura cerebri, the interpeduncular space, portions of the optic tracts with the optic commissure, the lamina cinerea, and portions of the third and fourth pairs of nerves. The interpeduncular space is situated between the diverging crura cerebri. It corresponds below to the deepest part of the cisterna pontis, and above to the posterior part of the floor of the third ventricle. It contains (1) the posterior perforated space, and in front of this (2) a pair of white rounded eminences, the corpora albicantia or mammillaria, and (3) a conical greyish elevation, the tuber cinereum, ending in a thin tubular process, the infundibulum. The latter passes to the pituitary body, from which it is detached in removing the brain by the ordinary method. Immediately in front of the tuber cinereum is the optic commissure, from which the optic tracts can be traced for a short distance backwards and outwards, winding round the crura cerebri, and finally disappearing under cover of the temporal lobes. A thin grey lamina, the lamina cinerea, passes from the anterior border of the optic commissure to the commencement of the great longitudinal fissure, where it gains an attachment to the rostrum of the corpus callosum. The crura cerebri appear as two strong flattened bundles of white fibres, which emerge from the superior border of the pons, and, diverging from one another, pass under cover of the temporal lobes, and are soon lost to view. On each side the third nerve is seen passing between the posterior cerebral and superior cerebellar arteries, it springs by a row of filaments from a groove at the inner margin of the crus. The fourth nerve, a slender rounded fasciculus, winds round the outer side of the crus. The pons Varolii appears immediately behind the crura as a broad band of white fibres directed transversely, and passing from one cerebellar hemisphere to the other. It narrows on each side as it passes into the cerebellum. It is marked by a shallow groove in the middle line in which the basilar artery rests. The fifth nerve is seen piercing the side of the pons near its upper border in the form of two bundles, a large posterior or sensory root, and a small anterior or motor root, separated from the former by some of the transverse fibres of the pons. The sixth nerves are seen at the lower border of the pons in the groove between it and the medulla, emerging from the latter close to the outer side of the pyramidal bodies or between the fibres of these bodies. The pyramidal and olivary bodies can readily be made out on the medulla, and a portion of the restiform body can also be seen without disturbing the parts. The twelfth or hypoglossal nerve emerges by a row of filaments from the groove between the olivary and pyramidal bodies. The ninth, tenth, and eleventh nerves, which appear in numerical order from above downwards, arise from the groove between the olivary and restiform bodies; the origin of the eleventh or spinal accessory nerve being continued down the lateral column of the cord. The seventh and eighth nerves are close to the edge of the pons in the angle between the latter and the cerebellum. The cerebellar hemispheres are placed one on each side of the medulla and conceal the occipital lobes of the cerebrum when viewed from the base. The cerebellum stands out conspicuously from the cerebrum on account of its darker grey colour and the smaller size and narrowness of its convolutions, which are termed **folia**. Two of its lobes are more prominent than the rest, viz. the **amygdalæ** or **tonsils**, which are placed close to the medulla, one on each side; and the **flocculi**, which lie close to the pons above the tenth or pneumogastric nerves.

FIG. 408.—VIEW OF THE BASE OF THE BRAIN. (After Beaunis.)


OLFACTORY BULB
OPERCULUM
2nd or OPTIC NERVE
3rd or OCULO-MOTOR
4th or TROCHLEAR
5th or TRIGEMINAL
6th or ABDUCENT
7th or FACIAL
8th or AUDITORY
9th, GLOSSO-PHARYNG.
10th. PNEUMO-GAST.
11th. SPINAL ACCESS.
12th. HYPO-GLOSSAL
TRIRADIATE FISSURE
ANTERIOR PERFORATED SPACE
PITUITARY BODY
TUBER CINEREUM
CORPUS ALBICANS
POST. PERF. SPACE
CRUS CEREBRI
PONS VAROLII
PYRAMIDAL BODY
OLIVARY BODY
AMYGDALA
SECTION OF SPINAL CORD
INFERIOR VERMIFORM PROCESS

THE CEREBRAL HEMISPHERES

The **cerebral hemispheres** constitute about 87.5 per cent. of the entire brain, and viewed from above, present an ovate form, broader behind than in front. They contain the lateral ventricles in their interior. They are separated from one another by the great longitudinal fissure, the floor of which is formed by the corpus callosum, a great commissure which connects each hemisphere with its fellow. Each hemisphere presents for examination four surfaces, supero-external, inferior, internal, and tentorial, and two extremities or poles, an anterior and a posterior; the **anterior pole** presenting an edge flattened internally and bevelled externally; the **posterior** forming a blunt rounded point which is directed backwards with an inclination downwards. With the exception of a small portion of the inferior surface, the cerebral hemispheres are entirely covered with **fissures** or **sulci**, which mark off intervening elongated elevations termed **convolutions** or **gyri.** By this means the surface area of the brain and consequently the proportion of grey to white matter is very greatly increased. The general arrangement of the convolutions in the two hemispheres of the same brain is tolerably symmetrical, but minor differences always occur. These differences are more particularly seen when there is any striking deviation from the normal arrangement, as such abnormalities are usually confined to one hemisphere. The **supero-external surface** is convex, presenting a sharper curve in the transverse than in the antero-posterior direction. It is marked off from the internal surface at the great longitudinal fissure by a well-defined edge. It is divided for about its middle third into a superior and an inferior segment by the horizontal limb of the fissure of Sylvius which lies above the temporo-sphenoidal lobe. The **internal surface** is flattened, and is separated from the opposite hemisphere by the falx cerebri and the subarachnoid space. The **inferior surface** is divided into two parts by the stem of the fissure of Sylvius; the posterior part is formed by the anterior end of the temporal lobe which is rounded and prominent, constituting the temporal pole. In front of the Sylvian fissure is the orbital area of the frontal lobe, which is concave and adapted to the orbital plate of the frontal bone. The **tentorial surface** is directed downwards and inwards; it is concave and rests upon the tentorium cerebelli.

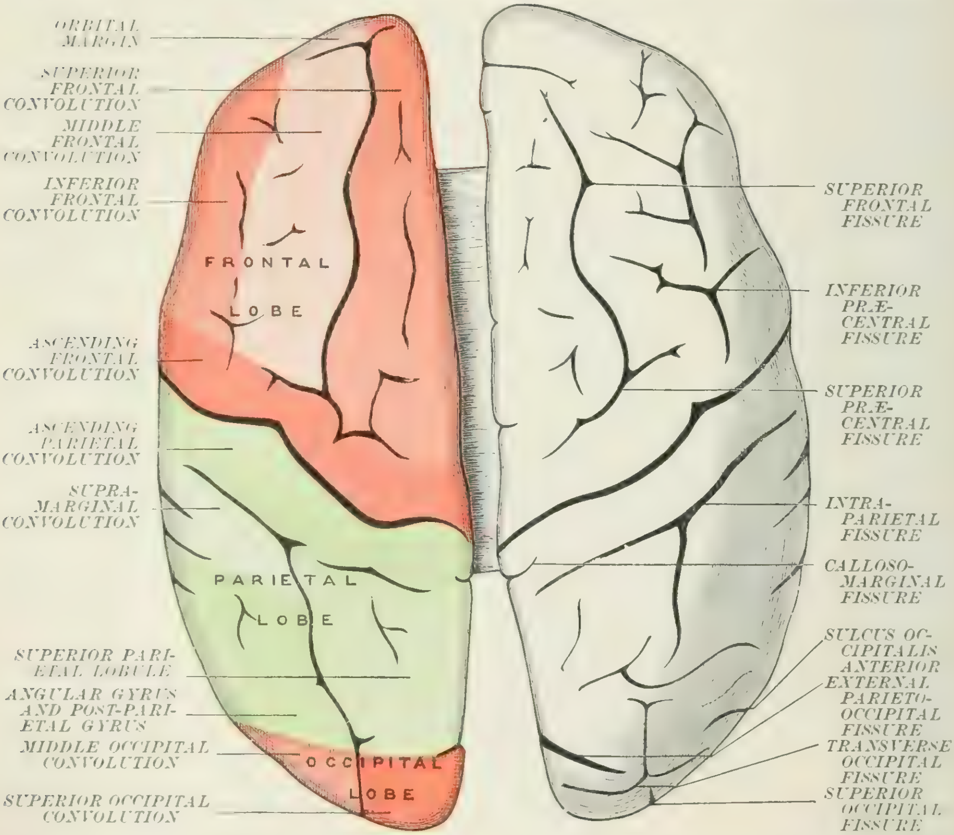
Fissures.—Under this term are included: (*a*) narrow intervals formed by the approximation of parts primitively widely separated, and (*b*) fissures due to infoldings of the ventricular wall for a part or the whole of its thickness. Only two fissures are included in the former category, viz. the great longitudinal and the great transverse fissures of the cerebrum. (*a*) The **great longitudinal fissure** extends from the frontal to the occipital pole of the cerebrum and separates the hemispheres from one another, except where they are joined by the corpus callosum. It contains the falx cerebri and the anterior cerebral vessels. The **great transverse fissure** will be described with the anatomy of the lateral and third ventricles. (*b*) The remaining fissures present a very distinct division into complete and incomplete. The complete fissures are formed by an infolding of the entire thickness of the ventricular wall, so that the reverse of each complete fissure appears as a bulging into the cavity of the ventricles. The complete fissures comprise the dentate fissure, the collateral fissure, the calcarine fissure, and parieto-occipital fissure. The fissure of Sylvius is sometimes described as a complete fissure, 'but the projection into the hemisphere cavity which corresponds with it (viz. the corpus striatum) is not formed by an infolding of the mantle wall, but as an elevation on the floor of the prosencephalon. The surface area corresponding to this internal projection does not keep pace with the mantle, as the latter grows around it, and in consequence the Sylvian depression makes its appearance.' (Cunningham.)

Interlobar fissures.—Certain fissures are termed interlobar because they have been selected to determine the boundaries of the various lobes into which the hemispheres have been (somewhat artificially) divided. These are the parieto-occipital fissure and the fissures of Sylvius and of Rolando.

The **parieto-occipital fissure** appears as a well-marked vertical sulcus on the posterior part of the inner face of the hemisphere, and is continued outwards for a short distance on to the convex surface. The portion on the mesial surface is distinguished as the **internal parieto-occipital** or **internal perpendicular fissure.** It will be more particularly described with the fissures and convolutions of the inner surface of the hemisphere. The portion which appears on the convex surface is distinguished as the **external parieto-occipital fissure.**

The **fissure of Sylvius** is situated partly on the base and partly on the external surface of the hemisphere, and is, with the exception of the great longitudinal fissure, the most conspicuous sulcus in the brain. It commences at the outer angle of a depression called the vallecula Sylvii, in which the anterior perforated space is situated. It passes outwards and upwards with an inclination backwards, and divides into three branches or limbs, a posterior, an ascending, and an anterior. The **posterior limb** is by far the largest, and is to be regarded as the continuation of the main fissure: it passes backwards and slightly upwards, separating the temporo-sphenoidal from the frontal and parietal lobes, and finally, taking a more upward direction, ends in the parietal lobe. The **ascending limb** is short and passes vertically upwards; the inferior frontal convolution arches around it. The **anterior limb** is about the same length as the ascending; it passes directly forwards into the substance of the inferior frontal convolution.

FIG. 409.—THE FISSURES AND CONVOLUTIONS OF THE CEREBRUM, VIEWED FROM ABOVE.

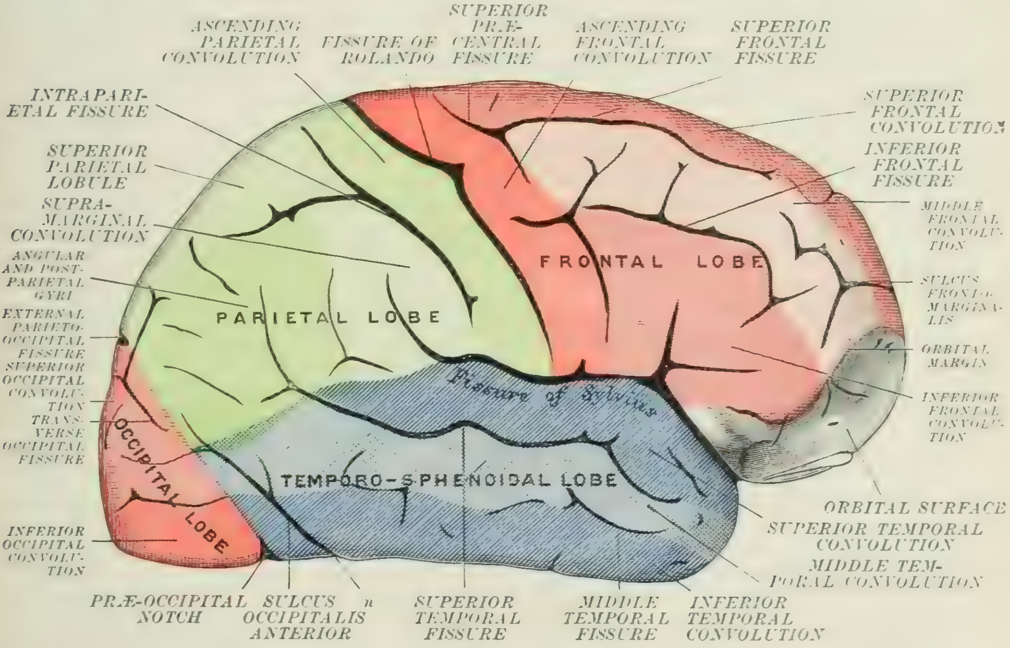

ORBITAL MARGIN
SUPERIOR FRONTAL CONVOLUTION
MIDDLE FRONTAL CONVOLUTION
INFERIOR FRONTAL CONVOLUTION
FRONTAL LOBE
ASCENDING FRONTAL CONVOLUTION
ASCENDING PARIETAL CONVOLUTION
SUPRA-MARGINAL CONVOLUTION
PARIETAL LOBE
SUPERIOR PARIETAL LOBULE
ANGULAR GYRUS AND POST-PARIETAL GYRUS
MIDDLE OCCIPITAL CONVOLUTION
OCCIPITAL LOBE
SUPERIOR OCCIPITAL CONVOLUTION
SUPERIOR FRONTAL FISSURE
INFERIOR PRÆ-CENTRAL FISSURE
SUPERIOR PRÆ-CENTRAL FISSURE
INTRA-PARIETAL FISSURE
CALLOSO-MARGINAL FISSURE
SULCUS OCCIPITALIS ANTERIOR
EXTERNAL PARIETO-OCCIPITAL FISSURE
TRANSVERSE OCCIPITAL FISSURE
SUPERIOR OCCIPITAL FISSURE

The convolutions which surround the fissure of Sylvius cover in and conceal the central lobe and are therefore called the opercula. The opercula are four in number—the temporal, the fronto-parietal, the frontal, and the orbital. The **temporal operculum** is formed by the upper temporo-sphenoidal convolution, the **fronto-parietal operculum** by the lower ends of the ascending frontal and parietal convolutions and the posterior end of the inferior frontal convolution.

The **frontal operculum** is the small part of the inferior frontal convolution inclosed between the ascending and the anterior horizontal limbs of the Sylvian fissure and the **orbital operculum** is the part of the inferior frontal convolution beneath the latter limb.

The **fissure of Rolando,** or **central sulcus,** serves as a line of demarcation between the frontal and parietal lobes. It is, next to the fissure of Sylvius, the most important of the incomplete fissures of the brain. It extends from the great longitudinal fissure to the Sylvian fissure, and may communicate with the latter (19 per cent., Cunningham), but the communication is always shallow. At its upper end it usually (60 per cent., Cunningham) passes into the great longitudinal fissure and appears on the mesial surface of the hemisphere, where it ends by bending backwards for about a quarter of an inch. The fissure of Rolando is directed downwards and forwards so that the fissures of the two sides taken together form an angle of about 143°, open in front. The fissure does not pursue a perfectly straight course, but is somewhat sinuous, and two of its bends, more conspicuous and constant than the others, have been described as the superior and inferior genua. These genua mark off the fissure into three approximately equal parts. The **superior genu** is directed backwards. The **inferior genu** looks forwards; it is more constant and much more strongly marked than the superior genu. In rare cases the fissure of Rolando may communicate with the praecentral or intraparietal sulci, but as a rule it pursues an isolated course across the convex surface.

FIG. 410.—LATERAL VIEW OF THE FISSURES AND CONVOLUTIONS OF THE CEREBRUM.


ASCENDING PARIETAL CONVOLUTION
FISSURE OF ROLANDO
SUPERIOR PRÆ-CENTRAL FISSURE
ASCENDING FRONTAL CONVOLUTION
SUPERIOR FRONTAL FISSURE
INTRAPARIETAL FISSURE
SUPERIOR FRONTAL CONVOLUTION
SUPERIOR PARIETAL LOBULE
INFERIOR FRONTAL FISSURE
SUPRA-MARGINAL CONVOLUTION
MIDDLE FRONTAL CONVOLUTION
ANGULAR AND POST-PARIETAL GYRI
FRONTAL LOBE
SULCUS FRONTO-MARGINALIS
PARIETAL LOBE
EXTERNAL PARIETO-OCCIPITAL FISSURE
ORBITAL MARGIN
SUPERIOR OCCIPITAL CONVOLUTION
Fissure of Sylvius
INFERIOR FRONTAL CONVOLUTION
TRANSVERSE OCCIPITAL FISSURE
OCCIPITAL LOBE
TEMPORO-SPHENOIDAL LOBE
ORBITAL SURFACE
SUPERIOR TEMPORAL CONVOLUTION
INFERIOR OCCIPITAL CONVOLUTION
MIDDLE TEMPORAL CONVOLUTION
PRÆ-OCCIPITAL NOTCH
SULCUS OCCIPITALIS ANTERIOR
n
SUPERIOR TEMPORAL FISSURE
MIDDLE TEMPORAL FISSURE
INFERIOR TEMPORAL CONVOLUTION

It has been very generally taught that the fissure of Rolando is caused by the pressure of a vein which passes during fœtal life (from the fourth to the sixth month) from the middle cerebral vein to the superior longitudinal sinus. This view has been recently disproved, as it has been shown that the fissure develops in two segments, an upper and a lower, and the fissure is afterwards completed by the sinking down of the central portion. The remains of this central elevation can always be seen on opening the fissure of Rolando as a deeply placed annectant or bridging convolution at the level of the superior genu. (Cunningham.)

The fissure of Rolando is one of the earliest of the incomplete fissures to appear, and is usually developed during the last week or ten days of the fifth month of intra-uterine life. By its transverse direction it interrupts the longitudinal course of the majority of the cerebral fissures;

this peculiarity is shared, however (but not so constantly), by the præcentral sulcus and by the vertical part of the intraparietal fissure. It is one of the most important landmarks on the cerebral surface, as the principal motor centres of the cortex are situated around it.

THE LOBES OF THE CEREBRAL HEMISPHERES WITH THE FISSURES AND CONVOLUTIONS

Each cerebral hemisphere is divided into five lobes, viz. the frontal, parietal, occipital, temporo-sphenoidal, and the central lobe or island of Reil. Four of these lobes are visible on the peripheral part of the hemispheres; the fifth, or island of Reil, is deeply placed and is concealed by the operculum.

Two other lobes, the limbic and the olfactory lobe, are also described.

The **FRONTAL LOBE** occupies the fore part of the hemisphere and presents three surfaces: a convex **supero-external** or **frontal,** an **inferior** or **orbital,** and an **internal** or **mesial.** The convolutions and fissures on the mesial and tentorial surfaces of the hemisphere will be described separately. The frontal lobe is bounded behind by the fissure of Rolando, and below, for about its posterior half, by the stem and posterior limb of the fissure of Sylvius. It is limited internally by the callosomarginal fissure.

The **frontal surface** is separated from the orbital by a well-marked angle which may be called the **orbital margin.** This margin is usually destitute of fissures, and forms a curve concentric with the orbital arch of the frontal bone. Three fissures on the frontal surface require description: one of these, running in a transverse direction, is termed the præcentral, the other two, which run parallel to the great longitudinal fissure, are named superior and inferior frontal.

The **præcentral sulcus** is placed in front of and parallel to the fissure of Rolando, and is usually divided by a sagittally-placed convolution into two parts, a superior and an inferior præcentral; the former is usually continuous with the superior frontal fissure.

The **superior frontal fissure** is sometimes discontinuous with the præcentral. At its orbital end it often passes into a coronally placed, curved fissure, termed the **sulcus fronto-marginalis.** The latter is situated just above the orbital margin of the frontal lobe.

The **inferior frontal fissure** may be continuous with the præcentral, but a narrow gyrus usually separates the two fissures.

The convolutions on the frontal surface are four in number: one directed transversely to the long axis of the cerebrum, the ascending frontal; and three lying in an antero-posterior direction, named superior, middle, and inferior frontal.

The **ascending frontal convolution** bounds the fissure of Rolando in front, and is placed between that fissure and the præcentral sulcus. It is connected at the lower end of the fissure of Rolando with the ascending parietal convolution, and passes into the paracentral lobule on the inner face of the hemisphere.

The superior, middle, and inferior frontal convolutions occupy the remainder of the frontal surface, and are marked off by the superior and inferior frontal sulci. They pass forwards, and become continuous with the convolutions on the orbital surface. They are not simple, but are traversed both in a coronal and sagittal direction by tertiary fissures.

The **superior frontal convolution** is continuous behind with the ascending frontal, and passes in front into the gyrus rectus and into the internal and anterior orbital convolutions. It is continuous with the marginal convolution on the inner face of the hemisphere.

The **middle frontal convolution** is continuous behind with the ascending frontal when the superior and inferior præcentral fissures are discontinuous. It passes in front into the anterior orbital gyrus. It is almost invariably continuous with the superior and inferior frontal convolutions at the orbital margin of the frontal lobe, and is often connected to these convolutions by secondary gyri passing across the superior and inferior frontal fissures.

The **inferior frontal convolution** is continuous behind with the ascending frontal, and joins the external orbital gyrus around the orbital margin. The ascending and anterior limbs of the fissure of Sylvius cut into the substance of this convolution, and divide it posteriorly into three parts, viz. pars orbitalis, pars triangularis, and pars basilaris. The **pars orbitalis** is situated below the anterior limb of the Sylvian fissure. The **pars triangularis** is included between the ascending and anterior limbs of the fissure. The **pars basilaris** is placed behind the ascending limb of the Sylvian fissure between the latter and the inferior præcentral sulcus.

This convolution is of great physiological interest, as the faculty of articulate speech is localised in its posterior part (Broca's convolution). Disease of this limited portion of brain substance on the left side produces aphasia, except in left-handed persons, in whom the speech-centre is placed in the corresponding position on the right side. The speech-centre is limited to the pars basilaris. According to Ferrier, the speech-centre includes (in addition to the above) the inferior extremity of the ascending frontal convolution and a small part of the ascending parietal immediately behind the lower end of the fissure of Rolando.

The **orbital surface** of the frontal lobe appears flattened in brains hardened in the ordinary manner; but when the brain is hardened *in situ* (fig. 410) it presents a very characteristic concavity, being moulded on the orbital plate of the frontal bone. The outer half of the orbital surface looks directly downwards, but the inner half, following the curve of the orbital plate, looks much more outwards than downwards, and forms a tolerably sharp edge where it meets the internal surface. Two fissures are situated on this surface, viz. the triradiate and the olfactory.

The **triradiate fissure,** as its name implies, is formed by three branches, which radiate from a common point. One branch is directed forwards, another backwards and inwards, and the third outwards. Another branch frequently springs from the external division near its centre, and in such cases the triradiate fissure assumes an **H**-shaped outline.

The **olfactory** or **straight sulcus** is placed a short distance external to the great longitudinal fissure, and lodges the olfactory tract and bulb.

The convolutions on the orbital surface comprise the three orbital convolutions and the straight convolution.

The **orbital convolutions** are wedge-shaped masses placed between the limbs of the triradiate fissure. They are called, from their position, **internal, anterior,** and **posterior.** They are continuous with the superior, middle, and inferior frontal convolutions respectively.

The **straight convolution,** or **gyrus rectus,** is situated between the sulcus of the same name and the margin of the great longitudinal fissure. It is continuous in front with the superior frontal convolution, and on the inner margin of the hemisphere with the marginal gyrus. It is sometimes described as a part of the internal orbital convolution.

The convolutions on the internal surface of the frontal lobe are the marginal and the paracentral. The student is recommended to defer the study of these till a later period (page 690).

The **PARIETAL LOBE** occupies the portion of the convex surface between the frontal and occipital lobes and above the temporo-sphenoidal lobe. It is bounded in front by the fissure of Rolando. Internally it is continued into the mesial surface of the hemisphere, where it is marked off from the adjacent lobes by the upturned end of the calloso-marginal fissure in front, by the internal parieto-occipital fissure behind, and more obscurely below by the variable **sulcus subparietalis.** On the convex surface of the hemisphere the posterior limits of the parietal lobe are in a great measure artificial. The external parieto-occipital fissure marks it off for a short distance, and the boundary is then crossed by convolutions termed annectant gyri, which run in a sagittal direction and so bring the parietal and occipital lobes into direct continuity. There is, however, a notch, the *præ-occipital notch* (fig. 410), placed at the lower margin of the hemisphere between the occipital and temporal lobes, and if a line be drawn from the extremity of the external parieto-occipital fissure to this notch, the upper part of the line, together with the external parieto-occipital fissure, separates the parietal from the occipital lobe. The parietal lobe is limited below by the posterior limb of the Sylvian fissure in the horizontal part of its course, and behind this its lower limits are artificially mapped out by producing the horizontal part of the Sylvian fissure backwards to meet the posterior boundary. The parietal lobe contains one fissure of importance—the intraparietal.

The **intraparietal fissure** is a system of three fissures, viz. a superior and an inferior vertical, placed parallel to the fissure of Rolando; and a horizontal placed at right angles to the other two. These parts may in rare cases remain separate, but most commonly are united with one another, forming a T-shaped figure. Moreover, the horizontal part may unite with a fourth part, the **ramus occipitalis,** which extends into the occipital lobe.

The intraparietal fissure has been hitherto regarded as consisting of an ascending and a horizontal part; the upper vertical limb (**postcentral sulcus**) being detached. This is a common variety of the fissure, but it has recently been shown that the T-shaped form is the commonest or normal arrangement. (Cunningham.)

The convolutions of the parietal lobe are: an ascending parietal, bounding the fissure of Rolando posteriorly and placed between that fissure and the intraparietal sulcus; and two parietal lobules, a superior and an inferior, placed above and below the horizontal limb of that fissure. The inferior parietal lobule is further subdivided into an anterior part called the supramarginal convolution, a middle, termed the angular gyrus, and a posterior part, the post-parietal convolution.

The **ascending parietal convolution** extends from the posterior limb of the Sylvian to the great longitudinal fissure, and is bounded in front by the fissure of Rolando, and behind by the intraparietal sulcus. It is continuous with the supramarginal convolution below the intraparietal fissure, and at its upper end is continued into the paracentral lobule on the inner surface of the hemisphere.

The **superior parietal lobule** is a squarish mass indented on the surface by tertiary fissures. It is limited internally by the margin of the great longitudinal fissure where it becomes continuous with the præcuneus. The anterior end of the ramus occipitalis of the intraparietal fissure terminates in this lobule when it is not continuous with the remainder of the intraparietal fissure, and, in such cases, the superior and inferior parietal lobules are continuous posteriorly. The superior parietal lobule is joined in front, by a convolution of variable breadth, with the ascending parietal, and is connected behind to the superior occipital convolution by the first annectant gyrus.

The **supramarginal convolution** is the anterior part of the inferior parietal lobule. It arches around the upturned extremity of the posterior limb of the fissure of Sylvius. It is continuous in front with the ascending parietal convolution, behind with the superior temporal gyrus and also with the angular gyrus. It is often very obscurely marked off from the latter.

The **angular gyrus** is placed behind the preceding and embraces the extremity of the parallel fissure. It is continuous behind with the middle temporal convolution. It is also usually connected to the middle occipital convolution by the third annectant gyrus.

The **post-parietal convolution** forms the posterior part of the inferior parietal lobule. It curves round the second temporal sulcus and joins the third temporal convolution.

The **OCCIPITAL LOBE** occupies, approximately, the portion of the cranial cavity which is interposed between the superior fossæ of the occipital bone and the tentorium cerebelli. It presents three very distinct surfaces: a convex supero-external, a mesial or internal, and a tentorial. The latter looks downwards and slightly inwards. These three surfaces meet at the occipital pole. It is sharply marked off on the mesial surface by the internal parieto-occipital fissure. On the convex surface the line of demarcation (as already described in treating of the parietal lobe) is made by drawing a line from the extremity of the external parieto-occipital fissure to the præoccipital notch (fig. 410). This line separates the occipital from the parietal and temporal lobes.

The **præoccipital notch** (fig. 410) is produced by the impression of the veins which enter the lateral sinus. Another impression (fig. 410, *n*), which is produced by the superior border of the petrous portion of the temporal bone, has been sometimes described as the præoccipital notch.

It is generally stated that the occipital lobe passes into the temporal lobe on the tentorial surface without any line of demarcation. A number of methods of marking off the occipital lobe have been proposed by different authors. These are all largely artificial. The occipital lobe is due to a backward growth common to the parietal and temporal lobes. That growth carries with it a prolongation of the lateral ventricle, forming the posterior cornu. The occipital lobe is therefore that part of the hemisphere which contains the posterior cornu. It may be marked off on the tentorial surface by a line drawn from the præoccipital notch to the extremity of the parieto-occipital fissure at the isthmus of the gyrus fornicatus (fig. 411). The remaining boundaries will be the parieto-occipital fissure for its entire length and (as before) a line drawn from the extremity of the external parieto-occipital fissure to the præoccipital notch.

The fissures on the convex surface of the occipital lobe are the superior, middle, and inferior occipital fissures; to these may be added the ramus occipitalis of the intraparietal fissure with its appendage the transverse occipital fissure.

The **superior occipital fissure** may be represented by a direct continuation of the intraparietal fissure to the occipital pole of the cerebrum. More commonly, however, it is limited to the posterior part of the occipital lobe (fig. 409, right side), and is not continuous with the intraparietal fissure. The **ramus occipitalis** of the intraparietal fissure may be directly continued into the occipital lobe from the horizontal limb of the main fissure, or it may commence in the superior parietal lobule. In either case it passes backwards into the occipital lobe between the first and second annectant gyri, and usually terminates a short distance behind the external parieto-occipital fissure by dividing into two branches which extend upwards and downwards at right angles to the main fissure, and together constitute the **transverse occipital fissure.**

The **middle occipital fissure** is often feebly developed. It is directed from before backwards and meets the superior occipital fissure at the occipital pole.

The **inferior occipital fissure** is placed along the margin which separates the convex surface from the tentorial surface of the hemisphere. It may extend in a tortuous manner from the præoccipital notch to the occipital pole of the hemisphere but is often broken up by one or more convolutions crossing it.

The convolutions on the convex surface are three in number, and are imperfectly marked off from one another by the fissures above described. They pass from before backwards and become confluent at the occipital pole.

The **superior occipital convolution** is placed between the superior occipital fissure and the margin of the great longitudinal fissure. It is continuous with the cuneus on the inner surface of the hemisphere, and is joined in front by the first annectant gyrus to the superior parietal lobule.

The **middle occipital convolution** is situated between the superior and middle occipital fissures, and is united in front to the post-parietal by the second and third annectant gyri.

The **inferior occipital convolution** occupies the interval between the middle and inferior occipital fissures, and may be connected to the middle temporal convolution by a fourth annectant gyrus.

The **annectant gyri** are four small sagittally-directed convolutions which cross the boundary line which separates the occipital from the parietal and temporal lobes. They are numbered from above downwards. The first and second of these are the most constant and are placed one on each side of the ramus occipitalis of the intraparietal fissure. The third and fourth are not infrequently absent as they may be cut through by a fissure, the **sulcus occipitalis anterior.**

The **sulcus occipitalis anterior** is an inconstant fissure which is parallel to, and placed a little in front of, the anterior boundary of the occipital lobe on the convex surface of the hemisphere.

The **TEMPORAL LOBE** (temporo-sphenoidal lobe) is sharply marked off in front by the Sylvian fissure, but, as we have already seen, it passes behind without any surface line of demarcation into the parietal and occipital lobes. Its anterior extremity forms a bold prominence directed downwards and forwards (the temporal pole of Broca). It has four surfaces: an external, forming part of the general convexity of the hemisphere; an inferior, which rests on the great wing of the sphenoid and the adjacent part of the petrous portion of the temporal bone; a tentorial and a superior, which is situated within the Sylvian fissure and can be displayed by pulling up the operculum.

The boundaries of the temporal lobe have been already indicated in the description of the other lobes, but may be recapitulated as follows. It is bounded behind by the lower part of the line drawn from the external parieto-occipital fissure to the præoccipital notch. Above, it is limited by the horizontal part of the posterior limb of the Sylvian fissure and by a line continuing the horizontal direction backwards to meet the posterior boundary. Its tentorial surface may be marked off from the occipital lobe by a line drawn from the præoccipital notch to the isthmus of the gyrus fornicatus.

Three fissures traverse the temporal lobe in a direction parallel to its long axis. The first of these, the superior temporal or parallel fissure, is one of the most constant of the incomplete fissures of the cerebrum. The other two, termed middle and inferior temporal, seldom appear as well-marked sulci, being as a rule broken up by fissures and gyri crossing at right angles to their direction.

The *collateral fissure* on the tentorial surface is approximately parallel to the three temporal sulci; it marks off the temporal from the falciform lobe.

The **parallel fissure** commences a short distance behind the apex of the lobe, and takes a course parallel to the posterior limb of the fissure of Sylvius. Its upturned extremity ends in the parietal lobe, where it is embraced by the angular gyrus.

The **middle temporal fissure** runs in the same general direction as the parallel fissure but is placed at a lower level. It may communicate behind with the sulcus occipitalis anterior.

The **inferior temporal fissure** is placed on the under surface near the lateral margin of the hemisphere. It is in a line with the inferior occipital fissure.

Three convolutions are present on the outer surface, running in an antero-posterior direction. They are termed the superior, middle, and inferior temporal convolutions. They become confluent with one another at the apex of the lobe.

The **superior temporal** or **inframarginal convolution** lies between the Sylvian and parallel fissures. It is continuous above with the supramarginal and angular gyri.

The **middle temporal convolution**, placed between the parallel and the middle temporal fissures, is continuous behind with the angular gyrus and the post-parietal convolution. It is usually joined to the inferior occipital by the fourth annectant gyrus.

The **inferior temporal convolution** is situated on the lateral margin of the hemisphere. It may be connected to the inferior occipital convolution by a fifth annectant gyrus.

The superior surface of the temporal lobe is in contact with the operculum. It is crossed by two or three (sometimes four) **transverse temporal convolutions.** (Heschl.)

Dissection.—The student should now raise the operculum and at the same time draw the temporal lobe downwards in order to bring the island of Reil into view. The large branches of the middle cerebral artery which lie among the convolutions of the island should be removed, together with the adherent pia mater.

The **CENTRAL LOBE** or **ISLAND OF REIL** corresponds to the floor of the embryonic **fossa Sylvii**, and is placed external to the claustrum. Its form is triangular; the base of the triangle is placed upwards and inwards, the apex forms a prominence, the limen insulæ, which separates the vallecula Sylvii from the fissure of the same name. It is hidden by the opercula and is surrounded, except at the limen, by a curved furrow, the **sulcus circularis Reilii** (Schwalbe). From five to seven convolutions, the **gyri operti**, radiate from the limen insulæ. The island is divided into a larger anterior part (**pars frontalis**), and a smaller posterior part (**pars parieto-falciformis**) by a constant fissure, the **sulcus centralis insulæ** (Hefftler and Eberstaller), which has the same direction, and is in the same plane, as the fissure of Rolando.

The pars parieto-falciformis is usually termed **pars temporo-parietalis**; a study of the development of this part of the island has shown, however, that it is connected with the falciform and not with the temporal lobe. (Cunningham.)

Dissection.—The student is recommended to defer the study of the convolutions on the mesial and tentorial surfaces of the hemisphere until the dissection of the corpus callosum is completed, and to proceed as follows. He should make a horizontal section through the uppermost part of the cerebral hemispheres; this will display the central core of white matter (**centrum ovale minus**) surrounded by a convoluted border of grey matter. Within the white matter a number of minute vessels will be seen which appear as bleeding points in a fresh brain (the **puncta vasculosa vel cruenta**). He may then remove successive thin sections until he reaches the level of the corpus callosum, the fibres of which, spreading out into the hemisphere, form an extensive white layer called the **centrum ovale majus**. A far more instructive dissection, however, can be made by cautiously tearing the brain substance in a direction from within outwards until the callosal fissure is reached. By the latter method the following points can be made out in an ordinary well-hardened brain: (1) The white fibres entering each convolution spreading out so as to end perpendicularly to the surface. (2) The fibres from the body of the corpus callosum passing at first horizontally outwards into the hemisphere and then diverging, some sweeping upwards to the parietal and frontal lobes, others bending downwards into the temporal lobe and following the long axis of that lobe. At the point where they bend downwards they readily break, as they are here intersected by fibres passing upwards from the inner capsule. (3) The fibres from the anterior and posterior extremities of the corpus callosum passing in a curved manner into the frontal and occipital lobes respectively, forming the **forceps minor** and the **forceps major**. (4) A set of fibres, known as the **cingulum**, which run within the gyrus fornicatus, forming a sagittally-directed arch. The dissector should next study the corpus callosum and the convolutions on the inner face of the hemisphere. The convolutions on the tentorial surface may be learned from a mounted specimen, or better still from a cast of a cerebral hemisphere, and the actual convolutions can be examined when the hemispheres are cut away from the mesencephalon at a later stage.

Mesial and tentorial surfaces of the hemisphere.—The **mesial surface** of the hemisphere is marked off from both the convex supero-external and the tentorial surface by the margin of the great longitudinal fissure. This margin follows a curved course as a well-defined border from the posterior extremity of the gyrus rectus as far as the occipital pole of the cerebrum. From this point it passes forwards and pursues a slightly curved course to the splenium of the corpus callosum immediately beneath which it ends. The latter part is termed by Schwalbe the **internal occipital border**; it is only seen in carefully-hardened brains, and appears as a rounded margin crossing the lobulus lingualis, and in front of this marking the gyrus fornicatus immediately above its isthmus (fig. 411). The **tentorial surface** is marked off from the supero-external surface by a well-defined border which extends from the occipital pole to the extremity of the temporo-sphenoidal lobe, forming a slight curve with the convexity upwards. The fissural system of the mesial and tentorial surfaces is of considerable importance and interest, as all the complete fissures of the cerebrum appear on these surfaces. These fissures are, as already mentioned, the internal parieto-occipital, the calcarine, the dentate, and the collateral. The calloso-marginal, a constant and important incomplete fissure, is also to be seen on the mesial surface.

The **calloso-marginal fissure** commences below the genu of the corpus callosum and pursues a curved course parallel to the corpus callosum until it reaches a point a short distance behind the upper extremity of the fissure of Rolando. It then bends upwards and extends on to the convex surface for a short distance, where it indents the upper end of the ascending parietal convolution. Two branches which pass from this fissure deserve special mention as, although not constantly present, they form useful lines of demarcation. One of these, the **sulcus paracentralis**, passes upwards between the paracentral and the marginal convolutions. Another, the **post-limbic** or **sulcus subparietalis**, passes backwards from the bend of the main fissure and separates the præcuneus from the gyrus fornicatus.

The **parieto-occipital fissure** commences at the isthmus of the gyrus fornicatus, and passes at first backwards and upwards, and then almost vertically upwards to reach the margin of the hemisphere, where it bends outwards and ends as the external parieto-occipital fissure.

The **calcarine fissure** commences by a bifid extremity near the occipital pole, and passes horizontally forwards with a slightly curved course to become confluent with the parieto-occipital fissure.

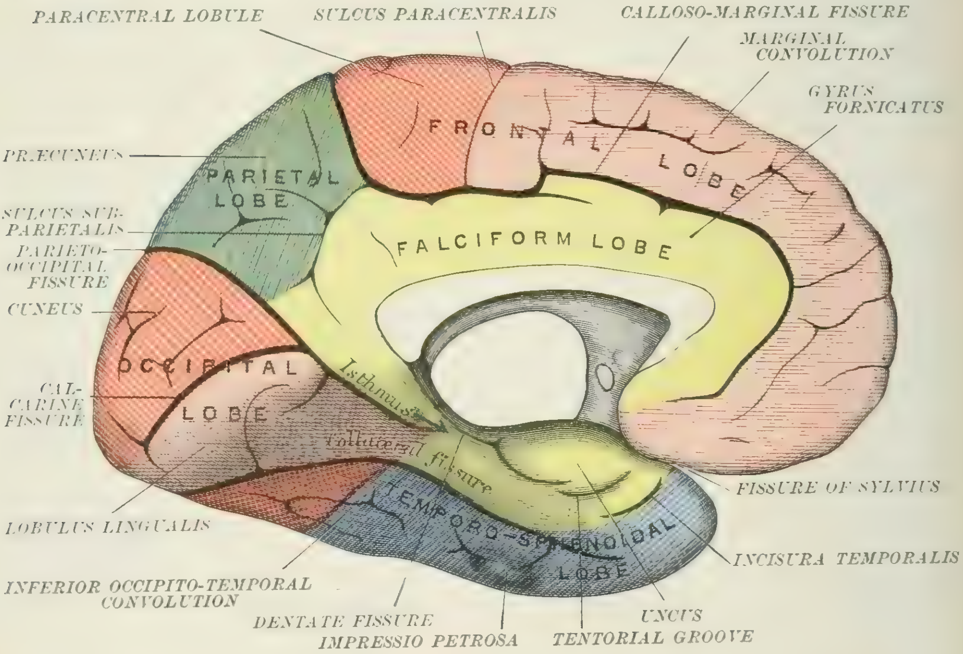
From what has been said, it follows that the internal parieto-occipital and calcarine fissures form by their union a Y-shaped figure. The hinder part of the stem of the Y and the fore part of the calcarine fissure produce an elevation within the posterior cornu of the lateral ventricle known as the hippocampus minor. It has been recently shown that in its development the stem of the Y may belong to the parieto-occipital fissure alone, or to the calcarine alone, or may be common to both. (Cunningham.)

The **callosal fissure** is a deep furrow which follows the curve of the corpus callosum, being placed between that body and the gyrus fornicatus. It commences below the rostrum of the corpus callosum and terminates behind the splenium, where it becomes continuous with the dentate fissure.

The **dentate** or **hippocampal fissure** extends from the splenium of the corpus callosum to the hooked extremity (**uncus**) of the uncinate gyrus. It produces an elevation in the descending cornu of the lateral ventricle, which is termed the hippocampus major.

The **collateral fissure** is common to the occipital and temporal lobes. It passes from a point on the under surface of the temporal lobe, near its apex, to the occipital pole of the hemisphere. The reverse of this fissure appears as an elevation (the **eminentia collateralis**) in the descending cornu of the lateral ventricle.

FIG. 411.—CONVOLUTIONS AND FISSURES ON THE MESIAL AND TENTORIAL SURFACES OF THE HEMISPHERE.


PARACENTRAL LOBULE
SULCUS PARACENTRALIS
CALLOSO-MARGINAL FISSURE
MARGINAL CONVOLUTION
GYRUS FORNICATUS
PRÆCUNEUS
SULCUS SUBPARIETALIS
PARIETO-OCCIPITAL FISSURE
CUNEUS
CALCARINE FISSURE
LOBULUS LINGUALIS
INFERIOR OCCIPITO-TEMPORAL CONVOLUTION
DENTATE FISSURE
IMPRESSIO PETROSA
TENTORIAL GROOVE
UNCUS
INCISURA TEMPORALIS
FISSURE OF SYLVIUS
FRONTAL LOBE
PARIETAL LOBE
FALCIFORM LOBE
OCCIPITAL LOBE
Isthmus
Collateral fissure
TEMPORO-SPHENOIDAL LOBE

The following convolutions appear on the mesial and tentorial surfaces:—

The **marginal convolution** commences below the rostrum of the corpus callosum and occupies the area of the mesial surface between the calloso-marginal fissure and the margin of the hemisphere as far as the paracentral sulcus. The latter separates it from the paracentral lobule. It is continuous around the margin of the hemisphere with the gyrus rectus, the internal orbital, and the superior frontal convolutions. It is marked by tertiary fissures along its whole course, in particular by a fissure which runs for some distance parallel to the calloso-marginal sulcus.

The **paracentral lobule** is bounded in front by the paracentral sulcus; below and behind by the calloso-marginal fissure. It is continuous around the margin of the hemisphere with the ascending frontal and ascending parietal convolutions; but as it is connected with the former by a much broader band than with the latter.

When the typical backward turn of the upper extremity of the fissure of Rolando is present, it hooks backwards into the forward bend formed by the upper extremity of the calloso-marginal fissure, and thus the frontal and parietal lobes are only connected by a narrow isthmus between the two fissures.

The **gyrus fornicatus,** or **gyrus cinguli,** which forms part of the limbic lobe, commences between the rostrum of the corpus callosum and the extremity of the marginal convolution, and, pursuing an arched course parallel to the corpus callosum, ends in a narrow convolution, the **isthmus,** which connects it to the uncinate gyrus. It is placed between the calloso-marginal and callosal fissures, and is thus clearly marked off from adjacent structures in the greater part of its extent, but is often very imperfectly separated from the superior parietal lobule. It may also be connected to the hinder end of the marginal convolution by a small gyrus crossing the calloso-marginal fissure.

The **præcuneus,** or **quadrate lobule,** is a squarish mass of small gyri which is continuous around the margin of the hemisphere with the superior parietal lobule. It is bounded, in front by the upturned end of the calloso-marginal fissure; behind, by the parieto-occipital fissure; and it may be marked off below, from the gyrus fornicatus, by the sulcus subparietalis.

The **cuneus,** or **cuneate lobule,** is a wedge-shaped mass occupying the interval between the internal parieto-occipital and calcarine fissures. It is continuous around the margin of the hemisphere with the superior occipital convolution. In a properly hardened right hemisphere it shows a distinct bevelling near the margin. This is produced by the impression of the superior longitudinal sinus. This bevelling can be traced downwards to the extremity of the lobulus lingualis, and less distinctly forwards to the præcuneus. In rare instances it may be seen in the left hemisphere instead of the right.

Two sagittally directed convolutions are situated on the tentorial surface. They are termed the **superior** and **inferior occipito-temporal convolutions.** The superior of these is divided into an anterior part called the uncinate gyrus, and a posterior part which is known as the lobulus lingualis.

The **uncinate convolution** commences behind at the isthmus, by which it is continuous with the gyrus fornicatus, and ends immediately behind the anterior perforated space in a hook-like elevation, the **uncus.** It is separated from the dentate convolution by the dentate fissure, it is marked off from the inferior occipito-temporal convolution by the collateral fissure and, in front of this, by the **incisura temporalis,** it forms part of the limbic lobe. The outer part of the anterior end is marked by a distinct groove, which, as it is produced by the free edge of the tentorium cerebelli, may be called the **tentorial groove** (fig. 411).

The uncinate convolution is covered with a peculiar fine network of white fibres, the **substantia reticularis alba.** These fibres are derived from the striæ longitudinales laterales which pass from the splenium of the corpus callosum on to the isthmus, and from thence to the uncinate gyrus.

The **dentate convolution** or **fascia dentata** will be more conveniently described with the anatomy of the lateral ventricle, as it is usually dissected in connection with that cavity.

The **lobulus lingualis** is the posterior part of the superior occipito-temporal convolution. It is bounded by the calcarine and parieto-occipital fissures above, and by the collateral fissure below. As the internal occipital border crosses this lobule it divides it into two parts, an upper part which appears on the mesial surface, and a larger lower portion situated on the tentorial surface.

The **inferior occipito-temporal convolution** extends from the apex of the temporal lobe to the occipital pole of the hemisphere. It is bounded above by the collateral fissure, and below by the inferior temporal and inferior occipital fissures. It is marked by the impressio petrosa at the junction of its anterior and middle thirds.

Three distinct impressions, which lie in a line with one another, are produced on the brain by the petrous portion of the temporal bone. One of these (fig. 410, *n*) corresponds to the portion of bone opposite the confluence of the superior petrosal with the lateral sinus. Another, the **impressio petrosa,** which may be large and conspicuous, is caused by the prominence of the superior semicircular canal. The third impression (**incisura temporalis**) is situated near the vallecula Sylvii, about one-third of an inch external to the tentorial groove.

The **LIMBIC LOBE** lies on the mesial and tentorial surfaces of the cerebrum. It is bounded externally by the calloso-marginal sulcus, the subparietal or post-limbic sulcus, the stem of the calcarine fissure, and the collateral fissure. It consists of an outer part formed by the callosal convolution, the isthmus and the uncinate gyrus, and an inner part in which are included the fornix, the septum lucidum, the striæ longitudinales mediales and laterales, and the fascia dentata, all of which will be subsequently described.

THE OLFACTORY LOBE.—The olfactory lobe attains a considerable size in some of the lower mammals, and in them it may contain a prolongation of the lateral ventricle in its interior; in seals it is small, in cetacea it is absent, and in monkeys and men it is rudimentary. Its anterior part is developed as an outgrowth of the cerebral vesicle, but the cavity, which is present at first, soon disappears in man, though its position is indicated, even in the adult, by the remains of the ependyma which lined it.

The olfactory lobe is divided into two lobules—the anterior and the posterior. The constituent parts of the **anterior olfactory lobule** are the bulb, the tract, the trigonum olfactorium, and the olfactory area of Broca. It is separated from the posterior olfactory area by a curved fissure, fissura prima, which runs outwards from the great longitudinal fissure in front of the anterior perforated space.

The **olfactory bulb** is an ovoid mass of gray and white matter a little more than a third of an inch long (1 cm.) and about a sixth of an inch (4 mm.) wide. It rests below on the cribriform plate of the ethmoid bone, and is lodged above in the olfactory sulcus on the orbital surface of the frontal lobe. About twenty olfactory nerves spring from its lower surface and pass through the foramina in the cribriform plate.

The **olfactory tract** is a triangular band of white matter which extends backwards from the posterior extremity of the bulb. It is about three-quarters of an inch long (2 cm.) and one-tenth of an inch broad (2.5 mm.). Its apex is embedded in the olfactory sulcus and its lower surface rests on the presphenoid bone (jugum sphenoidale). Posteriorly it terminates in two roots, the mesial and lateral, which enclose the trigonum olfactorium. The lateral root passes outwards and backwards across the anterior perforated space to the anterior end of the uncinate gyrus; the mesial root curves inwards behind Broca's olfactory area and becomes continuous with the lower end of the callosal gyrus. The anterior olfactory lobule is, therefore, intimately connected with the anterior part of the limbic lobe, the two together forming the rhinencephalon, or racquet-shaped lobe of Broca.

The **trigonum olfactorium** is a small triangular area of gray matter enclosed between the two roots of the olfactory tract and bounded behind by the fissura prima.

Broca's olfactory area is a small part of the posterior end of the gyrus rectus separated off from the remainder by a small oblique sulcus called the fissura serotina and bounded posteriorly and externally by the mesial root of the olfactory tract.

The **posterior olfactory lobule** is that portion of the gray cortex which forms the anterior perforated space. It is bounded internally by the peduncle of the corpus callosum, anteriorly by the fissura prima which separates it from the anterior olfactory lobule, and it extends externally into the vallecula Sylvii, being crossed by the lateral root of the olfactory tract.

THE CORPUS CALLOSUM is a great white transverse commissure which unites the cerebral hemispheres. Its form can be well studied in a mesial section of the brain (fig. 412), in which it appears as a longitudinal arch with rounded anterior and posterior extremities. The **posterior extremity** is called the **splenium**; it is rounded off behind and is formed by the corpus callosum doubling on itself, so that a small portion is folded forwards under, and in close opposition to, the larger part (fig. 413). The **anterior extremity** or **genu** is less sharply bent than the posterior end. It is continued downwards and backwards into a portion which appears

FIG. 412.—MESIAL SECTION OF ENTIRE BRAIN. (After Henle.)

The (*) points to the anterior extremity of the gyrus fornicatus; above it is the basal white commissure.

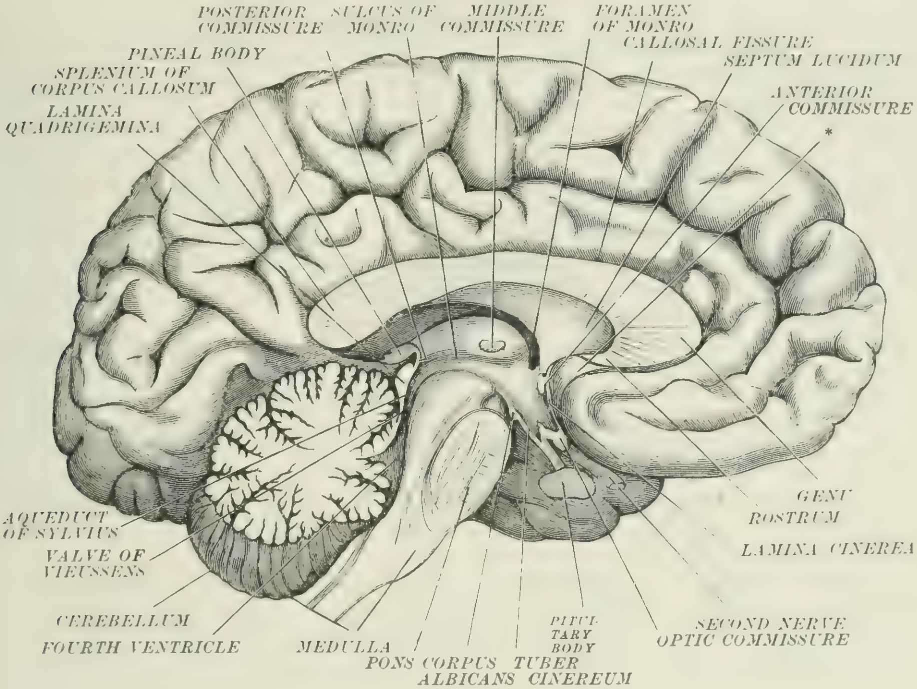
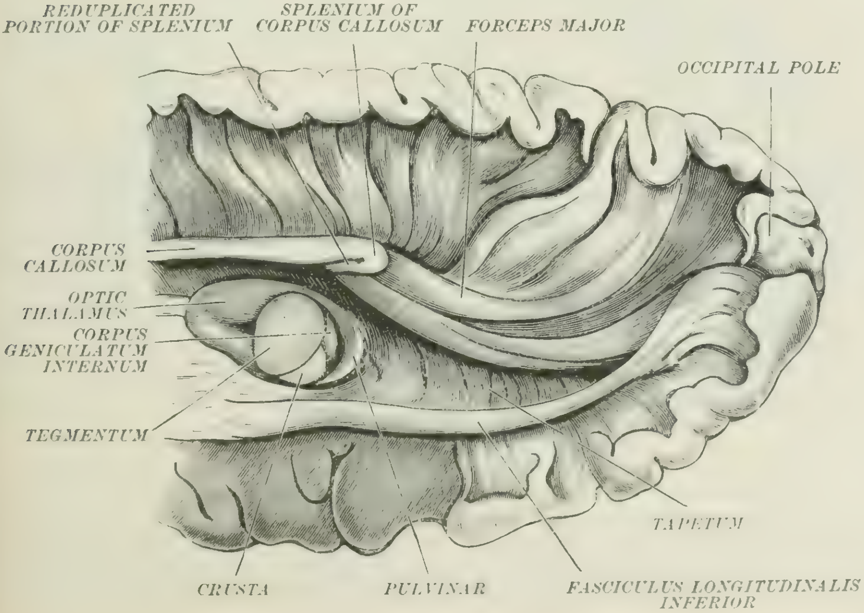

POSTERIOR COMMISSURE
SULCUS OF MONRO
MIDDLE COMMISSURE
FORAMEN OF MONRO
CALLOSAL FISSURE
SEPTUM LUCIDUM
PINEAL BODY
SPLENIUM OF CORPUS CALLOSUM
ANTERIOR COMMISSURE
LAMINA QUADRIGEMINA
*
AQUEDUCT OF SYLVIUS
GENU
ROSTRUM
VALVE OF VIEUSSENS
LAMINA CINEREA
CEREBELLUM
PITUITARY BODY
SECOND NERVE
OPTIC COMMISSURE
FOURTH VENTRICLE
MEDULLA
PONS
CORPUS ALBICANS
TUBER CINEREUM

FIG. 413.—A DISSECTION OF THE WHITE MATTER OF THE POSTERIOR PART OF THE RIGHT CEREBRAL HEMISPHERE.

(Viewed from the inner side. Schwalbe.)


REDUPLICATED PORTION OF SPLENIUM
SPLENIUM OF CORPUS CALLOSUM
FORCEPS MAJOR
OCCIPITAL POLE
CORPUS CALLOSUM
OPTIC THALAMUS
CORPUS GENICULATUM INTERNUM
TEGMENTUM
TAPETUM
CRUSTA
PULVINAR
FASCICULUS LONGITUDINALIS INFERIOR

pointed in section and is called the rostrum. The **rostrum** is connected to the lamina cinerea by a thin layer of white substance, the **basal white commissure.** The portion which intervenes between the splenium and rostrum, and which constitutes the greater part of the corpus callosum, is called the **body.** The under surface of the body is adherent behind to the fornix, and in front to the septum lucidum. In coronal sections (figs. 415 and 423) it can be seen that the under surface is free for some distance, except at its attachment in the middle line to the fornix and septum lucidum. This free portion forms the roof of the lateral ventricles. The upper surface remains free for a shorter distance than the lower, and ends at the floor of the callosal fissure, where the fibres of the corpus callosum enter the substance of the hemisphere. It forms in the transverse direction a gentle curve with the concavity directed upwards. Viewed from above, the corpus callosum is seen to present a transverse striation, this being an indication of the bundles of fibres passing from hemisphere to hemisphere. These transverse striations are crossed superficially by narrow longitudinal bands, the striæ longitudinales mediales and the striæ longitudinales laterales or tæniæ tectæ.

The **striæ longitudinales mediales** are placed one on each side of the middle line, and lie very close together, leaving a narrow interval between them which is called the **raphe.** Traced forwards, they slightly diverge and pass round the genu to the rostrum; here they separate more widely, and pass along the inner margin of the anterior perforated space, under the name of the peduncles of the corpus callosum, and are lost at the commencement of the fissure of Sylvius. Traced backwards each medial stria is found to be continuous at the splenium of the corpus callosum with the fasciola cinerea. This turns round the splenium and is continuous beneath it with the fascia dentata.

The **tæniæ tectæ,** or **striæ longitudinales laterales,** lie on the upper surface of the corpus callosum under cover of the callosal gyrus. They also can be traced backwards round the splenium into continuity with the fasciola cinerea. The medial and lateral striæ together represent the free margin of the gray matter on the inner surface of the brain, in the same way that the fascia dentata represents it on the tentorial surface, and they constitute the remains of a degenerated supracallosal gyrus.

The fibres of the corpus callosum after entering the cerebral substance spread out to every part of the hemispheres (with the exception of small portions of the temporal lobes) in the following sets :—

The **fibres from the genu** pass forwards and outwards into the anterior part of the frontal lobe, and then sweep inwards forming the **forceps minor.**

The **fibres from the body** have the following distribution :—The **uppermost fibres** pass outwards and then upwards, and finally curve inwards to the upper and mesial surfaces of the frontal and parietal lobes. The **intermediate fibres** pass transversely outwards to the same lobes. The **lowest fibres** form the roof of the lateral ventricle, and are separated from that cavity only by the ependyma and epithelium, and divide into anterior and posterior sets which are differently distributed. The **anterior set** ends in the opercula. The **posterior set** forms a layer called the **tapetum** which follows the descending and posterior cornua of the lateral ventricle, roofing over and bounding these cornua externally. The part which follows the descending cornu is destined for the temporal lobe. The portion which accompanies the posterior cornu passes to the under part of the occipital lobe.

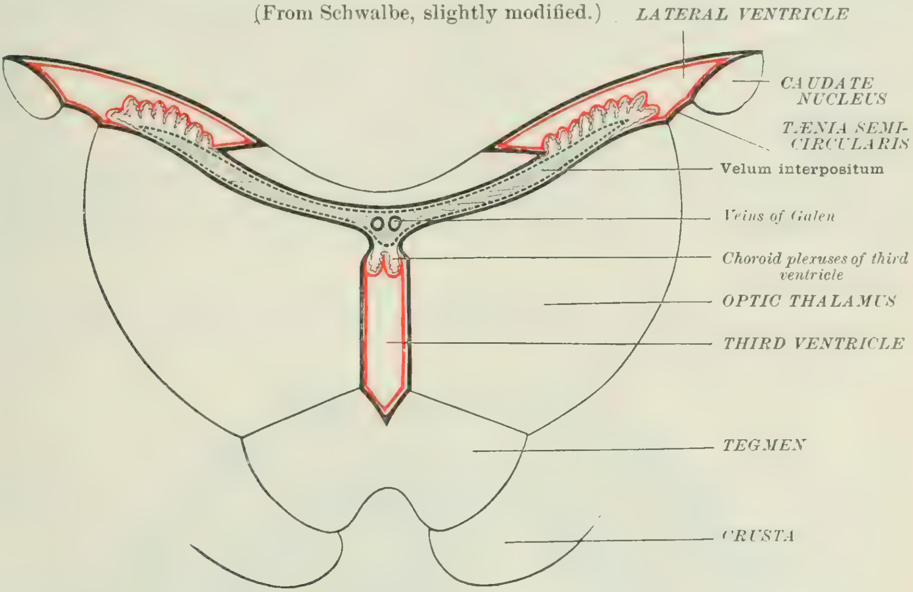
The **fibres from the splenium,** and from the part which is folded below it, pass backwards and outwards, and then sweep inwards forming the **forceps major,** the fibres of which pass to the posterior and upper parts of the occipital lobe.

Dissection.—Having completed the examination of the corpus callosum and of the mesial surface of the hemisphere, the student should next turn his attention to the lateral ventricles. The remaining fibres of the body of the corpus callosum should be divided a little to the right of the middle line and reflected outwards. This dissection will expose the body and anterior cornu of the lateral ventricle. The posterior and descending cornua should next be exposed by removing their outer walls.

THE LATERAL VENTRICLES are cavities in the cerebral hemispheres which are continuous with the third ventricle and with one another, through the foramen commune anterius (page 698). They are roofed over, as already described, by the corpus callosum, and are lined throughout by epithelium, which is reflected over the choroid plexuses, and is not continuous with the lining of the third ventricle except at the foramina of Monro. This epithelial lining forms the ventricular wall in the region of the so-called transverse fissure, through which the choroid plexus projects. This fissure is therefore not a breach in the ventricle, but simply a thin part of the wall through which the locally thickened pia mater (choroid plexus)

FIG. 414.—DIAGRAMMATIC CORONAL SECTION OF THIRD AND LATERAL VENTRICLES.

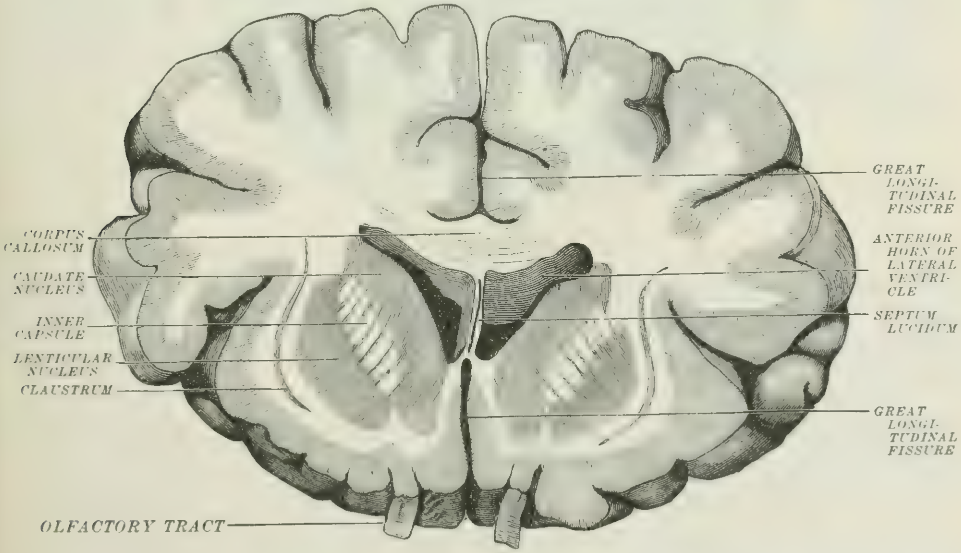
(From Schwalbe, slightly modified.)


LATERAL VENTRICLE
CAUDATE NUCLEUS
TÆNIA SEMICIRCULARIS
Velum interpositum
Veins of Galen
Choroid plexuses of third ventricle
OPTIC THALAMUS
THIRD VENTRICLE
TEGMEN
CRUSTA

The red lines indicate the epithelium.

FIG. 415.—CORONAL SECTION OF THE HEMISPHERES PASSING THROUGH THE ANTERIOR CORNUA OF THE LATERAL VENTRICLES.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)


GREAT LONGITUDINAL FISSURE
CORPUS CALLOSUM
ANTERIOR HORN OF LATERAL VENTRICLE
CAUDATE NUCLEUS
SEPTUM LUCIDUM
INNER CAPSULE
LENTICULAR NUCLEUS
CLAUSTRUM
GREAT LONGITUDINAL FISSURE
OLFACTORY TRACT

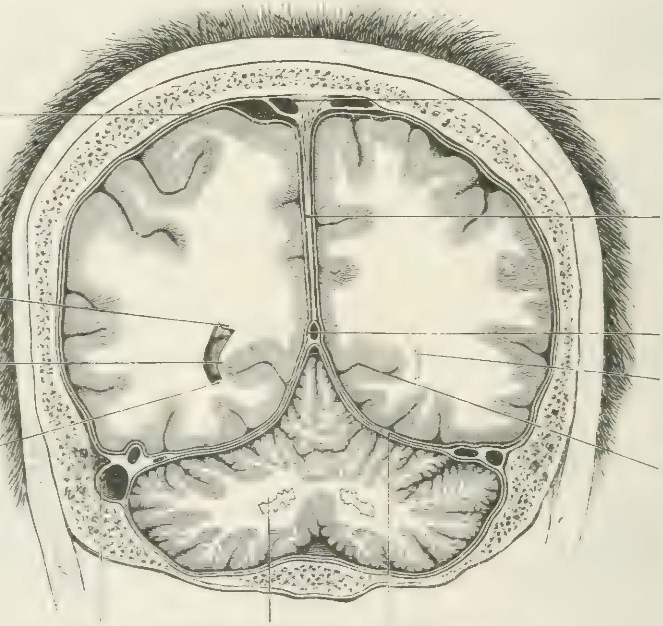
can be seen. Each lateral ventricle consists of a central part or body and three cornua: an anterior, an inferior or descending, and a posterior.

The **body** may be defined as the portion of the ventricle which extends from the foramen of Monro to the point where the cavity bifurcates into its posterior and descending cornua. It corresponds almost exactly in length to the portion of the optic thalamus which lies free within the ventricular cavity. It is greatest in its antero-posterior, and smallest in its vertical diameter. It is limited on the inner side by the attachment of the fornix to the corpus callosum, and by the narrow posterior part of the septum lucidum. On the outer side it is bounded by the fibres of the corpus callosum entering the substance of the hemisphere. Its floor looks upwards and slightly inwards, as can be well seen in coronal sections, and is formed by a series of structures which trend forwards with an inclination inwards. These structures are placed in the following order from without inwards:—the caudate nucleus of the corpus striatum, the tænia semicircularis and lamina cornea, the optic thalamus, the choroid plexus and the fornix (figs. 414 and 419).

The **anterior cornu** is directed forwards, downwards, and outwards. It appears crescentic in outline both in coronal and horizontal section. The concavity of the crescent looks downwards and outwards, and is caused by the projection of the caudate nucleus into the cavity. The anterior cornu is bounded internally by the septum lucidum, which forms a thin vertical partition between the anterior cornua of opposite sides, above and in front by the corpus callosum, and behind and externally by the head of the caudate nucleus.

FIG. 416.—Coronal Section of the Head passing through the Posterior Horns of the Lateral Ventricles.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)



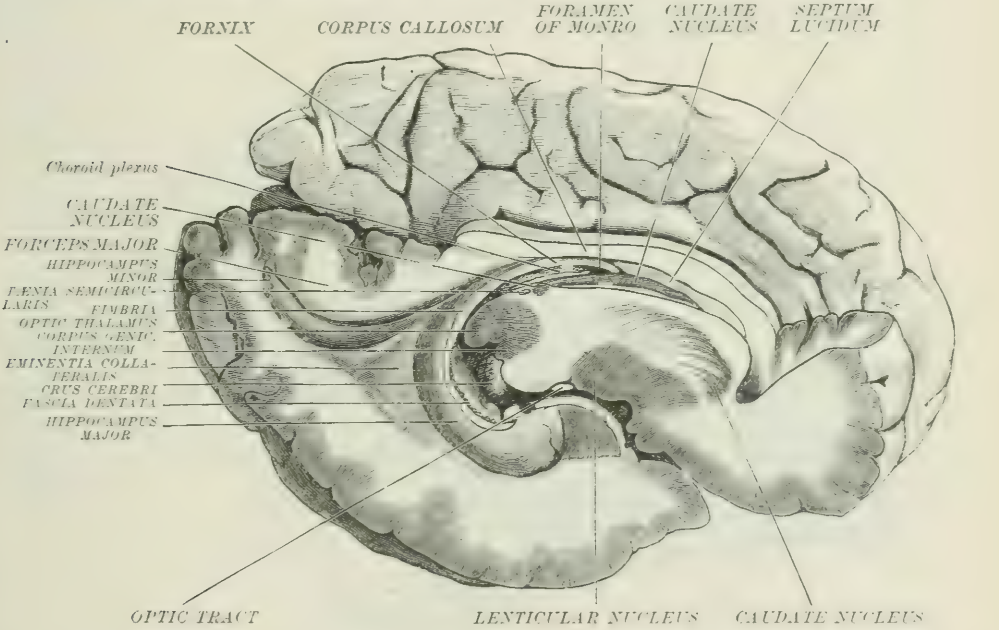
The **posterior cornu** is horizontal in its whole course, and is directed at first backwards and outwards, and afterwards backwards and inwards. It presents on its inner wall a curved prominence, the **hippocampus minor** or **calcar avis**; and above this a second prominence, the **bulb of the cornu**, which is caused by a part of the forceps major projecting into the cavity. The hippocampus minor is caused by a fold of the cerebral wall, and corresponds to the calcarine fissure on the mesial surface of the hemisphere (fig. 416). Its floor presents a slight elevation, caused by the fasciculus longitudinalis inferior.

Dissection.—The operculum should next be pulled upwards, when the small portion of substance still attaching it to the brain will be broken through. A complete view of the island of

Reil is then obtained. Lastly, the student should make a series of thin sagittal sections through the island of Reil and the frontal lobe until the great transverse fissure and its relation to the descending cornu of the lateral ventricle is seen (fig. 417). The sections will pass through the lenticular and caudate nuclei of the corpus striatum and through the optic thalamus.

The **inferior** or **descending cornu** pursues a more curved and complicated course than the other two cornua. It is directed at first outwards and backwards, and then bends somewhat sharply downwards; lastly, it sweeps forwards with an inclination inwards, following the long axis of the temporo-sphenoidal lobe. In transverse section it is seen to be somewhat triangular, presenting a floor, an inner wall, and a curved roof which bounds the cavity above and externally. The **floor** is formed by the eminentia collateralis. The following structures appear on the inner wall:—the hippocampus major, ending in the pes hippocampi; the corpus fimbriatum; and the choroid plexus, the latter apparently passing through a fissure (the great transverse fissure). The **roof** is formed from within outwards by the tænia semicircularis, by the narrow posterior prolongation of the caudate nucleus of the corpus striatum, and by the tapetum. At the extremity of the cornu the roof is formed by the amygdaloid tubercle. The tænia semicircularis and caudate nucleus may be traced to this tubercle.

FIG. 417.—A DISSECTION OF THE DESCENDING CORNU OF THE LATERAL VENTRICLE, WITH A SAGITTAL SECTION THROUGH THE BASAL GANGLIA.


FORNIX
CORPUS CALLOSUM
FORAMEN OF MONRO
CAUDATE NUCLEUS
SEPTUM LUCIDUM
Choroid plexus
CAUDATE NUCLEUS
FORCEPS MAJOR
HIPPOCAMPUS MINOR
TÆNIA SEMICIRCULARIS
FIMBRIA
OPTIC THALAMUS
CORPUS GENIC. INTERNUM
EMINENTIA COLLATERALIS
CRUS CEREBRI
FASCIA DENTATA
HIPPOCAMPUS MAJOR
OPTIC TRACT
LENTICULAR NUCLEUS
CAUDATE NUCLEUS

The **eminentia collateralis** is a smooth triangular elevation, which commences in the interval between the hippocampus major and minor, and extends, narrowing as it proceeds, nearly to the extremity of the descending cornu. It is the indentation of the ventricular wall produced by the collateral fissure.

The **hippocampus major, or cornu Ammonis,** is a curved white body which ends in a blunt extremity (pes hippocampi), on which are small indentations, giving it an obscure resemblance to the paw of an animal. It corresponds to the dentate fissure.

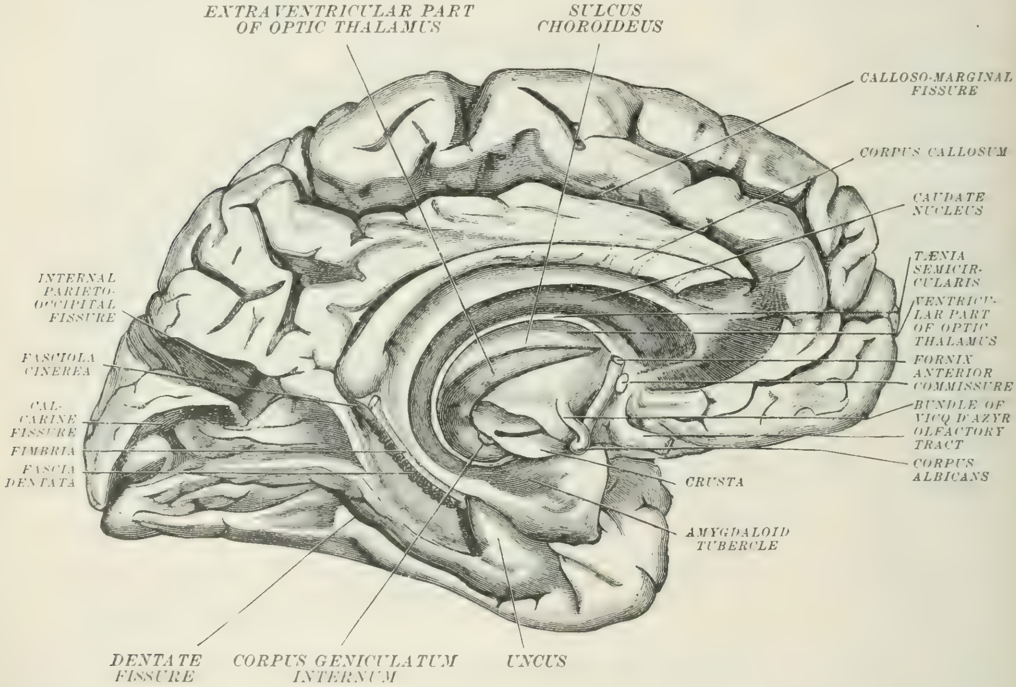
The **corpus fimbriatum, tænia hippocampi,** or **fimbria,** is a narrow strip of white matter with a somewhat wavy appearance, which is placed along the concave side of the hippocampus major. It is formed by a portion of the fibres of the fornix continued into the descending cornu, and presents apparently a free edge towards the transverse fissure, but is in reality continued into the epithelium which covers the choroid plexus. When this epithelium is torn through and the choroid plexus pushed forwards, the fascia dentata is exposed; the latter structure is placed above the dentate fissure, between the fimbria and the uncinate gyrus.

The **choroid plexuses** are vascular fringes formed by an infolding of the pia mater in the region of the so-called great transverse fissure. They extend from the termination of the descending cornua to the foramina of Monro, through which they disappear. The epithelial lining of the ventricle passes from the thin (apparently free) edge of the fimbria over the choroid plexus to the tænia semicircularis. This epithelium, which is the morphological wall of the cornu, excludes the choroid plexus (strictly speaking) from the ventricular cavity.

The **foramina of Monro** are the apertures through which the lateral ventricles communicate with the third ventricle, forming at their communication a Y-shaped passage, the **foramen commune anterius,** by means of which the lateral ventricles of opposite sides communicate with one another. The choroid plexuses of the lateral ventricles are continuous with one another through this passage. Each foramen of Monro is crescentic in outline, and is bounded in front and above by the anterior pillars of the fornix; below and behind by the anterior extremity of the optic thalamus; and behind by the reflexions of epithelium from the fornix and optic thalamus on to the choroid plexus.

FIG. 418.—A DISSECTION SHOWING THE FREE OR INTRAVENTRICULAR PORTION OF THE CAUDATE NUCLEUS. THE MESIAL AND TENTORIAL SURFACES OF THE HEMISPHERE ARE ALSO SHOWN.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)


EXTRAVENTRICULAR PART OF OPTIC THALAMUS
SULCUS CHOROIDEUS
CALLOSO-MARGINAL FISSURE
CORPUS CALLOSUM
CAUDATE NUCLEUS
TÆNIA SEMICIRCULARIS
VENTRICULAR PART OF OPTIC THALAMUS
FORNIX
ANTERIOR COMMISSURE
BUNDLE OF VICQ D'AZYR
OLFACTORY TRACT
CORPUS ALBICANS
CRUSTA
AMYGDALOID TUBERCLE
INTERNAL PARIETO-OCCIPITAL FISSURE
FASCIOLA CINEREA
CALCARINE FISSURE
FIMBRIA
FASCIA DENTATA
DENTATE FISSURE
CORPUS GENICULATUM INTERNUM
UNCUS

The **fascia dentata,** or **dentate convolution,** is the free edge of the grey matter of the hemisphere, and derives its name from its characteristically notched or indented appearance. It is placed above the dentate fissure, and follows this fissure upwards towards the splenium of the corpus callosum, where it becomes continuous with the fasciola cinerea. The **fasciola cinerea** is a grey lamina resembling the fascia dentata but with a smooth margin. It ends just above the splenium of the corpus callosum.

Dissection.—The student should slice away the left hemisphere and expose the lateral ventricle of that side, leaving the central portion of the corpus callosum *in situ* for the present. He should then make a series of horizontal sections through the island of Reil and corpus striatum of the left side. If he has carried out the dissection as recommended on the right side, he will now be in a position to study the corpus striatum both in horizontal and vertical section, and at the same time to examine its intraventricular part more fully. The horizontal sections will pass through both nuclei of the corpus striatum with the inner and outer capsules, the claustrum, and a portion of the optic thalamus (fig. 419).

BASAL GANGLIA OF THE HEMISPHERES

A series of ganglionic masses is placed in the base of each cerebral hemisphere. They are subjacent (with the exception of the amygdaloid nucleus) to the island of Reil and form, with that lobe, the oldest part of the hemisphere; that is to say, they constitute the portion which is (as already mentioned) the first to appear both in the vertebrate series and also in the development of the individual. They are all semi-detached local thickenings of the grey cortex, and may be enumerated as follows:—the corpora striata, each composed of two nuclei, the nucleus caudatus and the nucleus lenticularis; the claustra, and the amygdaloid nuclei. The optic thalami are in close proximity to the corpora striata, but belong to the thalamencephalon. Certain important fasciculi of white matter are intimately related to the corpora striata. The chief of these white fasciculi are the inner and outer capsules, the anterior commissure, and the tænia semicircularis.

The **nucleus caudatus** is an elongated mass of grey matter somewhat resembling a pear with a long curved stalk. It presents a free, or ventricular, surface, and a surface which is embedded in the hemisphere. It is thickest at the anterior end, or **head.** The free surface of the anterior thickened portion looks upwards and inwards, and bulges into the anterior horn of the lateral ventricle. Thence it ascends with an inclination outwards to the body of the ventricle, where it forms the outermost constituent of the floor of that cavity, and narrows into the commencement of the tail. In this situation it is separated from the optic thalamus by the lamina cornea and tænia semicircularis. The **tail** of the nucleus caudatus then passes into the descending cornu. It is placed at first in front of the cornu, afterwards forms part of the roof of that cavity, and ends at the amygdaloid tubercle. The deep surface of the caudate nucleus is separated from the nucleus lenticularis by a layer of white matter called the inner capsule. The two nuclei are, however, connected by bands of grey matter which intersect the fibres of the anterior limb of the inner capsule, and they are directly continuous for a short distance in front.

The **nucleus lenticularis** is embedded in the substance of the hemisphere except at the base of the brain, where it comes to the surface for a small part of its extent at the anterior perforated space. Here it is continuous externally with the claustrum and, as before stated, with the nucleus caudatus. In horizontal section it appears like a bi-convex lens, with its surface directed outwards and inwards, the outer surface forming a curve of larger radius than the inner. In sagittal section the lenticular nucleus is also somewhat lens-shaped in outline (fig. 417). In coronal sections through the anterior part it appears crescentic, with the convexity turned downwards and outwards (fig. 415); but in successive sections taken from before backwards the crescentic gives place to a triangular or wedge-shaped outline (fig. 421). In fresh brains this grey mass can be seen to be traversed by thin white intersections, the **internal** and **external medullary laminæ**, which divide it into three zones. The middle and inner zones are of a yellowish grey colour, and constitute the **globus pallidus.** The outer zone is of a darker reddish grey, and is traversed with fine white striæ. It is called the **putamen.**

The **putamen** is the longest part of the lenticular nucleus, and is the only portion of that body which is continuous with the caudate nucleus.

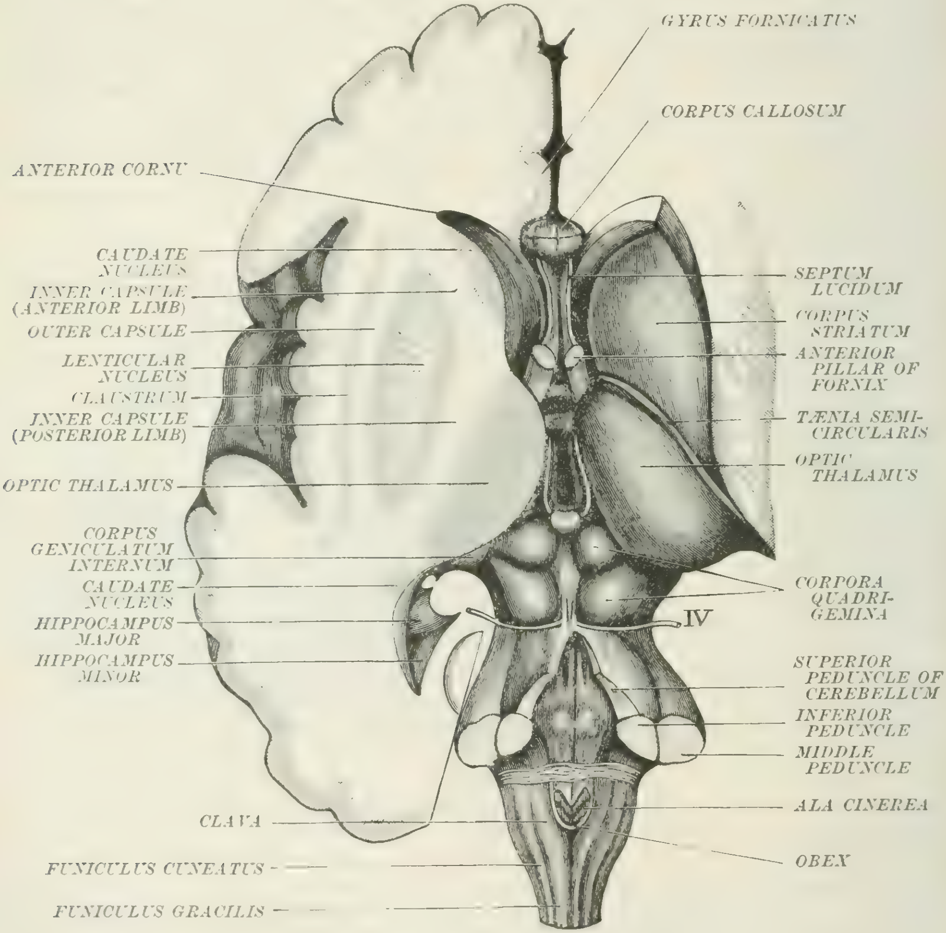
The above agrees substantially with the account which is given by Schwalbe: this anatomist, however, describes the amygdaloid nucleus as discontinuous with the tail of the caudate nucleus. According to Foster and Sherrington, the globus pallidus of the lenticular nucleus as well as the putamen is continuous with the caudate nucleus.

A band of white fibres, the **ansa lenticularis,** passes inwards below the inner capsule. It emerges from the under surface of the lenticular nucleus, being continued from the medullary laminæ. It also receives fibres from the inner segment of the globus pallidus. The ansa lenticularis enters the subthalamic region and passes beneath the red nucleus, where it becomes indistinct.

The **claustrum** is a thin band of grey matter which is placed, nearly vertically, external to the lenticular nucleus, and separated from the latter, except at its lower part, by the outer capsule. It is separated from the grey matter of the island of Reil by a layer of white matter, into which it sends small pointed processes corresponding to the gyri operti of the island. It is fused at its anterior end with the amygdaloid nucleus. (Hill.)

Fig. 419.—Horizontal Section of the Cerebrum.

(After Landois and Stirling.)


GYRUS FORNICATUS
CORPUS CALLOSUM
ANTERIOR CORNU
CAUDATE NUCLEUS
INNER CAPSULE (ANTERIOR LIMB)
OUTER CAPSULE
LENTICULAR NUCLEUS
CLAUSTRUM
INNER CAPSULE (POSTERIOR LIMB)
OPTIC THALAMUS
CORPUS GENICULATUM INTERNUM
CAUDATE NUCLEUS
HIPPOCAMPUS MAJOR
HIPPOCAMPUS MINOR
CLAVA
FUNICULUS CUNEATUS
FUNICULUS GRACILIS
SEPTUM LUCIDUM
CORPUS STRIATUM
ANTERIOR PILLAR OF FORNIX
TÆNIA SEMICIRCULARIS
OPTIC THALAMUS
CORPORA QUADRIGEMINA
IV
SUPERIOR PEDUNCLE OF CEREBELLUM
INFERIOR PEDUNCLE
MIDDLE PEDUNCLE
ALA CINEREA
OBEX

The **amygdaloid nucleus** is a thickening of the grey cortex of the apex of the temporal lobe, and produces a bulging (amygdaloid tubercle) into the roof of the extremity of the descending cornu of the lateral ventricle.

The **tænia semicircularis,** or **stria terminalis,** is a band of fibres which passes upwards and backwards from the anterior pillar of the fornix, traversing the groove between the caudate nucleus and the optic thalamus. It accompanies the caudate nucleus into the roof of the descending cornu, and ends in the amygdaloid nucleus. In its course along the groove above mentioned it is partly covered by the vein of the corpus striatum and by a thickened band of ependyma, the **lamina cornea,** which also covers the vein.

The **inner capsule** is a broad band of white fibres which is placed on the inner side of the nucleus lenticularis. In horizontal section it presents an anterior limb between the two nuclei of the corpus striatum, and a posterior limb which separates the nucleus lenticularis from the optic thalamus. These two limbs meet at an angle salient inwards. This angle is called the **genu,** and is placed adjacent to the tænia semicircularis.

In vertical section the inner capsule presents a beautiful arched arrangement of radiating white fibres (fig. 417).

The **outer capsule,** much narrower than the inner, is a band of white fibres which intervenes between the claustrum and the nucleus lenticularis.

In a horizontal section through the basal ganglia of the hemisphere and adjacent part of the thalamencephalon, an alternation of grey and white layers is seen in the following order from without inwards:—(1) the grey matter of the island of Reil; (2) the white matter of the same lobe; (3) the claustrum; (4) the outer capsule; (5) the nucleus lenticularis; (6) the inner capsule; (7) the nucleus caudatus and optic thalamus, separated from one another by the tænia semicircularis (fig. 419).

The **anterior commissure** bounds the third ventricle in front, but belongs to the cerebral hemispheres, as it is developed in connection with the lamina terminalis. It presents a cylindrical free surface towards the third ventricle, where it appears like a small transverse bar in the interval between the anterior pillars of the fornix. It passes outwards in front of the fornix, and traverses the cerebral substance below the lenticular nucleus on each side (fig. 421), the fibres inclining backwards and assuming a twisted arrangement as it proceeds. It ends in the temporal lobe.

Dissection.—The student should cut through the remaining part of the corpus callosum about the middle, raise the posterior portion, carefully detaching it from the subjacent fornix, and throw it backwards. This dissection will reveal the body and the diverging posterior pillars of the fornix. He should then raise the anterior portion of the corpus callosum, and snip through the septum lucidum with a sharp pair of scissors. The slit-like fifth ventricle will now be visible, or may be brought into view by gently separating the laminæ of the septum lucidum with the point of the scalpel. The fornix should next be examined and then divided by cutting through its body and throwing the parts backwards and forwards. By this dissection the so-called transverse fissure will be opened up and the velum interpositum exposed.

The **FORNIX** is a longitudinally-arched bundle of fibres composed of two symmetrical halves which are united together at the central part, forming the body, but diverge in front and behind, constituting the anterior and posterior pillars. The **body** forms a curve parallel to the corpus callosum, to the under surface of which it is adherent.

It is narrowest and thickest in front, widest and thinnest behind. It lies on the velum interpositum, which separates it from the third ventricle and from the optic thalami. The outer portions of its upper surface are placed in the body of the lateral ventricles, covered by the epithelium which passes at the thin outer margin of the fornix into the epithelial covering of the choroid plexuses. The **posterior pillars** diverge from the body, passing backwards and outwards. In the interval between them the splenium of the corpus callosum can be seen if viewed from below. This is marked by faint longitudinal, transverse, and oblique lines, and is described as the **lyre.** The posterior pillars expand as they pass outwards and enter the descending cornua of the lateral ventricles. A conspicuous bundle of fornix fibres passes along the concave border of the hippocampus major as the **fimbria,** which can be traced to the uncus. Other fibres are scattered over the hippocampus major and the eminentia collateralis. The **anterior pillars** sweep downwards with a sharper curve than the corpus callosum, and so diverge from it, leaving an interval which is occupied by the septum lucidum. They descend, in the form of two rounded slightly-diverging bundles, immediately behind the anterior commissure. Here they are joined by the tæniæ semicirculares, and receive fibres from the peduncles of the pineal body and from the septum lucidum. In this situation they present a free surface, except in front, where they give attachment to the septum lucidum. Having reached the base of the brain, they end in the grey nuclei of the corpora albicantia.

The anterior pillars of the fornix were formerly described as twisting on themselves to form bends or loops in the base of the brain, the **corpora albicantia**, the fibres after forming the bend being continued upwards on the inner sides of the descending anterior pillars as the **bundles of Vicq d'Azyr.** This description is borne out by naked eye dissection, but it has been shown that the bundles of Vicq d'Azyr are discontinuous with the fornix fibres. (Forel and Gudden.)

The **septum lucidum** is formed by thin portions of the hemisphere walls, which have become approximated and in part fused, but are separated in the greater part of their extent by the fifth ventricle. It appears as two closely approximated thin vertical laminae, separating the anterior cornua of the lateral ventricles of opposite sides. It is attached above and in front to the under surface of the body and back of the genu of the corpus callosum, below to the rostrum and to the basal white commissure, and behind to the anterior pillars of the fornix. Viewed from the side, it is triangular in outline, with an acute angle directed backwards and occupying the narrow interval between the front of the body of the fornix and the corpus callosum (fig. 412).

Each of the two laminæ which constitute the septum lucidum contains three layers : a layer of ependyma and epithelium next the lateral ventricle, a middle layer of white fibres, and a layer of rudimentary grey matter next the fifth ventricle. A layer of connective tissue immediately bounding the fifth ventricle (rudimentary pia-matral layer) is described by Testut.

The **fifth** or **Sylvian ventricle** is a narrow, sagittally-directed, slit-like cavity which originally formed a part of the great longitudinal fissure. It lies between the layers of the septum lucidum and it does not communicate with any of the true ventricles of the brain.

The **great transverse fissure of the cerebrum** is of a horse-shoe shape, and extends from the foramen of Monro on each side to the termination of the descending cornu of the lateral ventricle. It is not a fissure in the sense of forming a communication between the ventricles and the exterior of the brain, but it may be considered as a fissure in the same sense that we use the term 'complete fissure.' If we compare it with the adjacent dentate fissure, we find that the latter produces a bulging (the hippocampus major) into the ventricular cavity. This bulging contains an inner layer of white and an outer layer of grey matter, and is simply a fold of the ventricular wall, which is here thinner than elsewhere. The floor of the dentate fissure is occupied by pia mater. Now if we suppose the substance of the hippocampus thinned away until only the epithelial lining of the ventricle was left, this epithelium would come in contact with the external pia mater, and an arrangement resembling the choroid plexus, coming through a fissure, the hippocampal fissure, would be produced. The choroid plexus is therefore an internal convolution reduced to a layer of epithelium forming the morphological wall of the ventricle, and produced by a fissure, the great transverse fissure, which is occupied by a specialised and highly vascular part of the pia mater. In comparing the great transverse fissure with the complete fissures of the cerebral hemispheres, however, we must not lose sight of the fact that it is not limited to the hemisphere wall (except at its extremities in the temporal lobes), but is produced, for the greater part of its extent, by the folding of the prosencephalon over the thalamencephalon (page 670). According to Merkel and Mierzejewsky, small slit-like apertures are found in the region of the transverse fissure near the termination of the descending horn of the lateral ventricle. These place the cavity of the lateral ventricle in communication with the subarachnoid space.

The **velum interpositum,** or **tela choroidea superior,** is a large triangular fold of pia mater which overlies the third ventricle. The body and posterior pillars of the fornix and the splenium of the corpus callosum rest on its upper surface. It is continuous laterally with the choroid plexuses of the lateral ventricles, which are simply the convoluted and highly vascular margins of the fold. Traced backwards, the layers are seen to divaricate and to become continuous with the pia mater covering the tentorial surface of the occipital lobes and the upper surface of the cerebellum. Two large veins, the veins of Galen, commence at the anterior extremity of the velum interpositum. The veins of Galen are chiefly formed by the veins of the corpora striata, and are continued backwards in the middle line to end in the straight sinus. In this course they lie in a prolongation of the subarachnoid space between the two layers of pia mater which form the velum interpositum, and usually unite into one vein before entering the straight sinus.

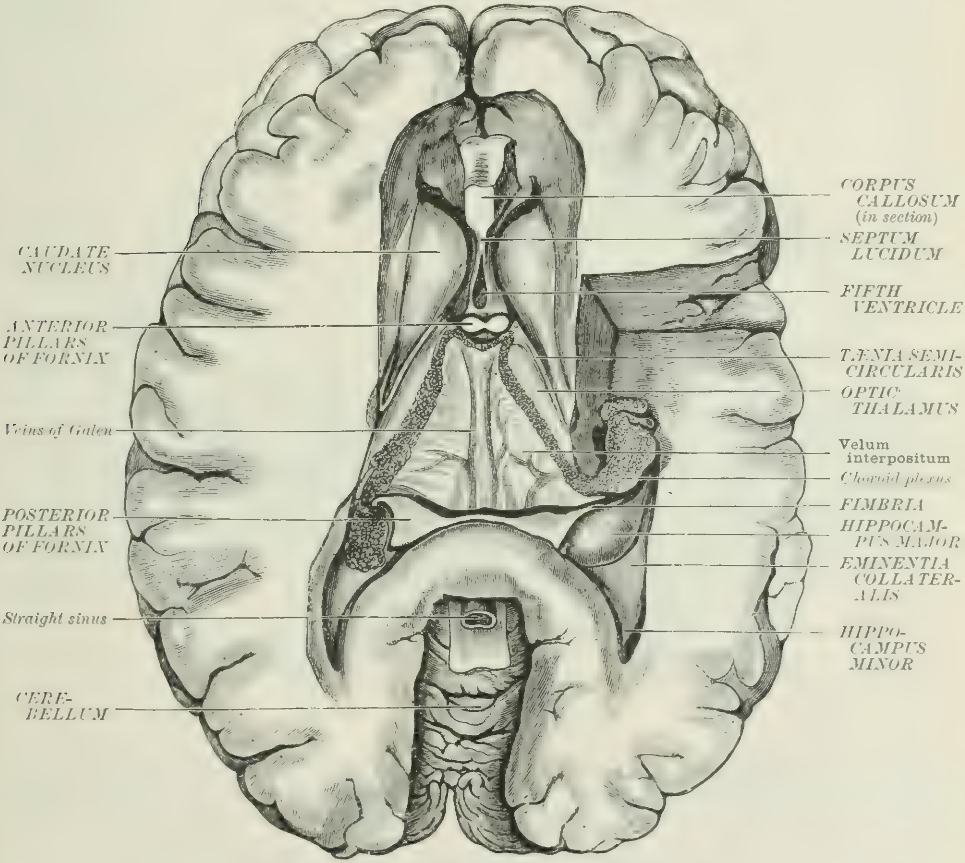
The under surface of the velum interpositum rests on the inner parts of the optic thalami, and between the latter it is placed directly over the third ventricle, where it is covered by a layer of epithelium continuous with the lining of that cavity, but discontinuous with the epithelium of the lateral ventricles, except at the foramina of Monro.

The **choroid plexuses** extend from the extremity of the descending cornu of each side to the foramen of Monro where they become continuous with one another through the foramen commune anterius. From the junction of the two plexuses a pair of small vascular fringes pass backwards on the under surface of the velum interpositum in the middle line, and depend into the cavity of the third ventricle, constituting the choroid plexuses of that cavity (fig. 414). The anterior choroid artery enters the choroid plexus at the termination of the descending cornu: other smaller arteries are supplied to the plexus from behind, and are derived from the posterior cerebral artery.

FIG. 420.—HORIZONTAL SECTION OF THE CEREBRAL HEMISPHERES.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)

(The fornix has been reflected to show the velum interpositum.)


CAUDATE NUCLEUS
ANTERIOR PILLARS OF FORNIX
Veins of Galen
POSTERIOR PILLARS OF FORNIX
Straight sinus
CEREBELLUM
CORPUS CALLOSUM (in section)
SEPTUM LUCIDUM
FIFTH VENTRICLE
TÆNIA SEMICIRCULARIS
OPTIC THALAMUS
Velum interpositum
Choroid plexus
FIMBRIA
HIPPOCAMPUS MAJOR
EMINENTIA COLLATERALIS
HIPPOCAMPUS MINOR

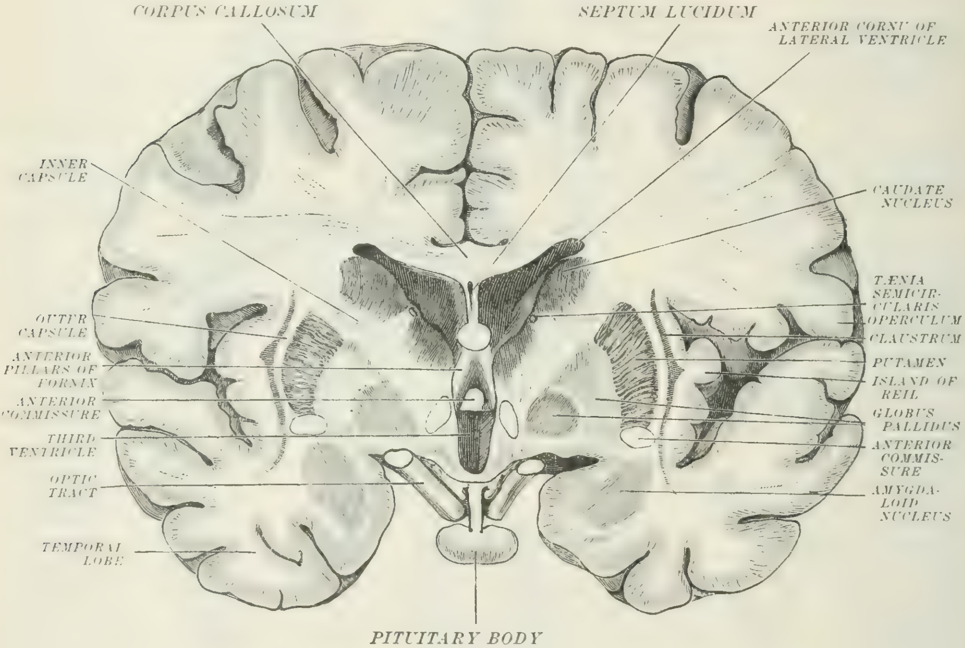
Dissection.—The student should divide the splenium of the corpus callosum in the middle line, and remove the portions of the hemispheres which lie posterior to the great transverse fissure; they will readily separate at the fissure, and break off at the extremities of the temporal lobes. This operation should be conducted with gentleness, as the walls of the third ventricle are very prone to become unduly divaricated by this dissection. The part removed should be re-examined, as the relations between the fissures and hippocampi can be studied to great advantage at this stage. The cavity of the third ventricle may now be displayed by raising the velum interpositum, and reflecting it backwards. This must be done cautiously, as the pineal body is closely enfolded in the posterior part of the under layer of that membrane, and an attempt should be made to retain it in its proper place. The dissector should thoroughly examine the cavity and floor of the third ventricle and the free surfaces of the optic thalami, but he is recommended to dissect the deep surfaces of the latter bodies in connection with the mesencephalon.

THE THALAMENCEPHALON

The **THIRD VENTRICLE** is a narrow cavity whose lateral walls are so closely approximated that in coronal sections it appears as a vertical slit. It communicates in front with the lateral ventricles by the foramina of Monro. Behind, it is continuous with the fourth ventricle through a narrow passage, the aqueduct of Sylvius. The opening into the aqueduct is bounded above by a transverse white bundle of fibres, the **posterior commissure**; and, above this, a prolongation of the ventricular cavity extends into the stalk of the pineal body, in which it ends blindly. The third ventricle is covered by the corpus callosum, the fornix, and the velum interpositum; its true roof, however, is formed by the epithelium lining the under surface of the last-named structure. The central part of its cavity is crossed transversely by the **middle or grey commissure.** It is bounded, laterally by the optic thalami, and in front by the anterior pillars of the fornix and by the anterior commissure. It is limited behind by the commencement of the aqueduct of Sylvius, by the posterior commissure, and by the reflexion of epithelium from the upper surface of the pineal body on to the under surface of the velum interpositum. In the anterior part of the ventricle the floor is marked off from the lateral walls by the anterior pillars of the fornix, which, after forming part of the anterior boundary, sweep backwards with an inclination downwards: in this situation they are covered by a thin layer of the central grey substance of the ventricle, and project as slight ridges. The third ventricle is relatively shallow for about the posterior third of its extent, but in its anterior two-thirds it presents a deep recess which is divided into an anterior and a posterior part by a prominent ridge. This

FIG. 421.—CORONAL SECTION THROUGH THE ANTERIOR PART OF THE THIRD VENTRICLE.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)


CORPUS CALLOSUM
SEPTUM LUCIDUM
ANTERIOR CORNU OF LATERAL VENTRICLE
INNER CAPSULE
CAUDATE NUCLEUS
TÆNIA SEMICIRCULARIS
OPERCULUM
OUTER CAPSULE
CLAUSTRUM
ANTERIOR PILLARS OF FORNIX
PUTAMEN
ISLAND OF REIL
ANTERIOR COMMISSURE
GLOBUS PALLIDUS
THIRD VENTRICLE
ANTERIOR COMMISSURE
OPTIC TRACT
AMYGDALOID NUCLEUS
TEMPORAL LOBE
PITUITARY BODY

ridge is formed by the junction of the tuber cinereum and the lamina cinerea above the optic commissure. The **floor** is formed by the following structures:—behind, by the tegmental portion of the diverging crura cerebri, and between them by the posterior perforated space; in front of this by the corpora albicantia, the tuber cinereum with the infundibulum and the lamina cinerea. The latter slopes upwards to the anterior commissure, and is relegated by some anatomists to the anterior wall instead of to the floor.

The **central grey matter of the third ventricle** is continuous behind with the grey matter of the aqueduct of Sylvius, and passes in front into the basal grey commissure. It also covers the lower parts of the internal surfaces of the optic thalami, and gives a thin covering to the anterior pillars of the fornix and to the bundles of Vicq d'Azyr.

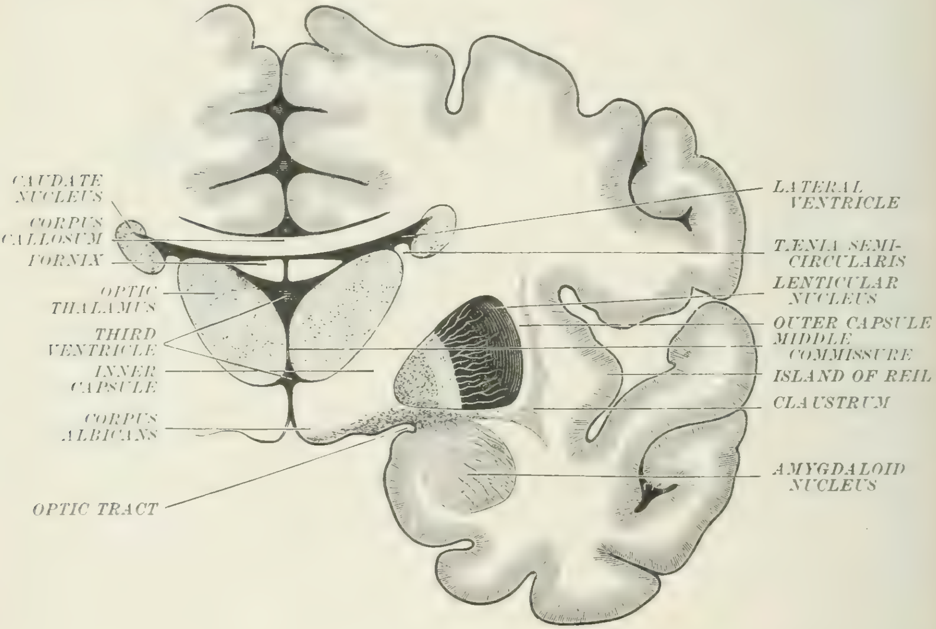
The **optic thalami** are a pair of large ganglia placed one on each side of the third ventricle. Each optic thalamus is a short prismatic body whose long axis is directed forwards and inwards. This axis is not straight, but is slightly curved with its convexity upwards. The thalamus presents an anterior and a posterior extremity or tubercle, and four surfaces: a superior and an internal which are free, and an inferior and an external which are imbedded in the cerebral substance. The **anterior tubercle** is a blunt rounded point which forms the posterior boundary of the foramen of Monro. The **posterior tubercle,** or **pulvinar,** is broader than the anterior, and is compressed from above downwards. It is directed backwards and downwards; it is continued externally into the outer geniculate body, and overhangs the inner geniculate body. It is placed above and in front of the descending cornu of the lateral ventricle, but is separated from the cavity of the latter by the choroid plexus. The **superior surface** shows a slight convexity, more pronounced in the antero-posterior than in the transverse direction. It is covered with a layer of white fibres. It presents a groove, the **sulcus choroideus,** which underlies the free edge of the fornix, separated from the latter only by the velum interpositum. This groove marks off an antero-external area, wider in front than behind, which ends in the anterior tubercle and which forms part of the floor of the lateral ventricle. Internal to the sulcus choroideus is a larger area, which is covered by the fornix and velum interpositum. This area is limited internally for about its anterior half by the **stria pinealis,** or **peduncle of the pineal body,** a white bundle of fibres which runs along the sharp edge which separates the superior from the median surface. The posterior part of this area slopes gradually into the pulvinar. Between the superior surface and the posterior part of the stria pinealis is a small triangular area, the **trigonum habenulæ,** which is sunk below the level of the adjacent part of the thalamus. The **internal surface** is nearly flat and bounds the cavity of the third ventricle, towards which it presents a slight convexity. It is of a pale-grey colour owing to a thick layer of ependyma covering the ganglionic substance, and is united to its fellow of the opposite side by a broad band of grey matter, the **middle** or **grey commissure** (**commissura mollis**). It is crossed at its lower margin by a groove, the sulcus of Monro, which passes from the foramen of Monro to the commencement of the aqueduct of Sylvius. The **external surface** rests against the fibres of the inner capsule behind the genu, being separated from the nucleus lenticularis by the inner capsule. The **inferior surface** is placed over the crus cerebri, on the tegmental part of which it rests.

In coronal sections through the posterior part of the thalamus, the external surface is seen to be separated from the inferior surface by a distinct angle; but in similar sections through the anterior part the two surfaces pass into one another, the angle being rounded off. The grey substance of the thalamus is indistinctly marked off into three nuclei: an **antero-superior,** an **external,** and an **internal.** The largest part of the antero-superior nucleus forms the anterior tubercle; the thinner portion passes backwards above and between the other two nuclei; its shape has been not inaptly compared to that of the caudate nucleus. A remarkable bundle of white fibres, the **ansa lenticularis,** passes below the optic thalamus and inner capsule from the lenticular nucleus of the corpus striatum.

The **pineal body** (**epiphysis cerebri** or **conarium**) is a reddish-grey body about the size of a cherry-stone. It has the form of a flattened cone, compressed from above downwards. Its long axis is directed forwards and slightly upwards. Its base is directed forwards and passes into a bilaminar stalk. Its superior surface is covered by epithelium for the anterior two-thirds or three-fourths of its extent, and bounds in part the cavity of the third ventricle. Its inferior surface rests in the mesial groove between the superior quadrigeminal bodies, separated from the latter by a fold of pia mater. The **stalk** of the pineal body is continuous by its lower lamina with the posterior commissure. Its upper lamina passes into the **peduncle** or **stria pinealis**, which passes at first outwards, and then forwards, along the margin of the optic thalamus which separates the upper and mesial surfaces of that body; it then crosses the floor of the foramen of Monro and joins the anterior pillars of the fornix.

The **recessus pinealis** is a diverticulum from the cavity of the third ventricle, which extends into the stalk and a short distance into the body of the conarium. Within the pineal body, and in the adjacent part of the velum interpositum, a number of gritty particles (acervulus cerebri, brain sand) are found. These particles consist chiefly of phosphate and carbonate of calcium. The pineal body was formerly described as a gland (pineal gland) but is now known to be a rudimentary unpaired eye. This pineal eye lies close to the surface in some of the lower vertebrates, and was probably functional at a former period. A great parietal foramen in the extinct reptile Ichthyosaurus is strongly suggestive of a functional pineal eye.

FIG. 422.—CORONAL SECTION THROUGH THE MIDDLE COMMISSURE OF THE THIRD VENTRICLE. (Schwalbe.)



The **posterior commissure** is a transverse band of fibres which projects into the posterior part of the cavity of the third ventricle (page 708).

The subthalamic tegmental region and the corpora geniculata will be more conveniently described with the mesencephalon.

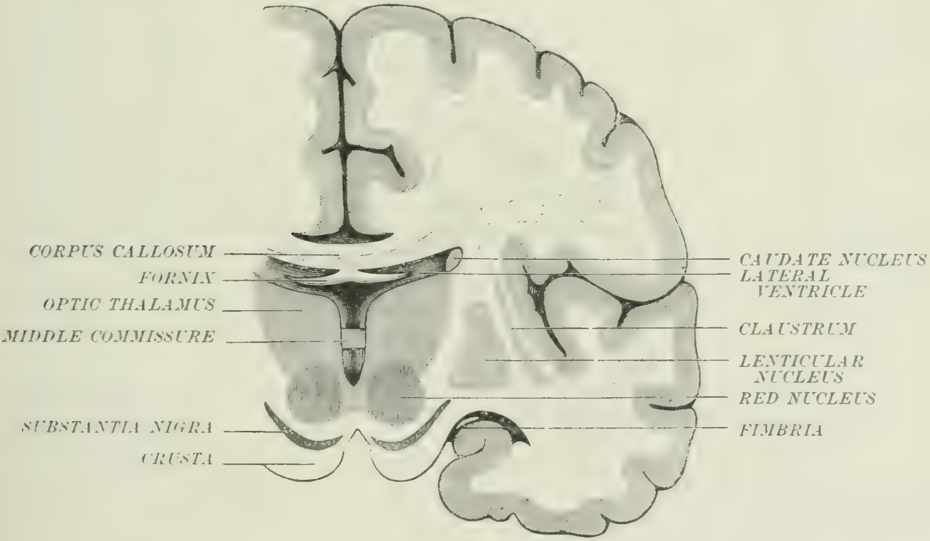
The **basal grey commissure** is a continuous plate of grey matter which is formed from behind forwards by the posterior perforated space, the tuber cinereum, and the lamina cinerea.

The **posterior perforated space** is a stratum of grey matter which is perforated by a number of small vessels derived from the commencements of the posterior cerebral and superior cerebellar arteries. It occupies the back part of the interpeduncular space and extends for a short distance under cover of the pons, where it bounds a recess, the **foramen cæcum anterius**. It is continuous laterally with the grey matter of the tegmenta of the crura cerebri, and is attached in front to the corpora albicantia. The portion of the space which is situated in front of the exit of the third nerve forms part of the floor of the third ventricle; the posterior part belongs to the mesencephalon.

The **corpora albicantia** appear as a pair of white knobs in the base of the brain. Each contains in its interior a grey nucleus. This nucleus is joined by the anterior pillar of the fornix and the bundle of Vicq d'Azyr of the same side. The **bundle of Vicq d'Azyr** passes upwards and forwards through the grey matter of the optic thalamus to the anterior tubercle of that body.

The **tuber cinereum** is a grey elevation placed immediately behind the optic commissure. It is the largest part of the basal grey commissure, and is continuous laterally, above the optic tracts, with the grey cortex of the temporal lobes (fig. 421). In front it passes over the optic commissure into the lamina cinerea. It is continued below into a conical process, the **infundibulum,** which is directed downwards and slightly forwards, through the central opening in the diaphragma sellæ to end in the posterior lobe of the pituitary body. The upper part of the infundibulum is hollowed out by a diverticulum of the third ventricle, the **recessus infundibuli.** The tuber cinereum and infundibulum correspond to the median recess in the floor of the third ventricle.

FIG. 423.—CORONAL SECTION THROUGH THE THIRD VENTRICLE BEHIND THE MIDDLE COMMISSURE. (Gegenbaur.)



The **pituitary body,** or **hypophysis cerebri,** is a small ellipsoidal body which is lodged in the pituitary fossa of the sphenoid bone. Its long axis is directed transversely, and its antero-posterior and vertical diameters are about equal.

The pituitary body consists of two distinct lobes, an anterior and a posterior. The **anterior lobe** is of a reddish-grey colour, and is considerably larger than the posterior lobe, which it partially embraces. The **posterior lobe,** of a yellowish-grey colour, is lodged in a recess in the anterior lobe, and is the only part connected with the infundibulum.

This body was formerly described as the **pituitary gland,** because it was supposed to secrete the **pituita,** or mucus of the nose. According to Gaskell's ingenious theory, the infundibulum is the mouth of an archaic alimentary canal. The ventricular system of the brain is the rudiment of the cephalic stomach as found in Arthropods. The central canal of the spinal cord is the archaic intestine, and the neuro-enteric canal (an embryonic communication between the neural tube and the intestine) connects this archaic intestine with the ano-rectal region. This pituitary body is of great interest in the light of this theory, as it brings the archaic mouth to the surface. The posterior lobe is developed in connection with the brain, but the anterior lobe is formed independently. It originates as an upward growth of the epiblastic invagination which forms the mouth, and is afterwards cut off by the chondrification and subsequent ossification of the skull.

The **optic commissure** is formed by the union and partial decussation of the optic tracts of opposite sides. Each optic tract may be traced backwards from the commissure, around the crus cerebri, to the region of the corpora geniculata (page 710).

The **lamina cinerea** is a thin plate of grey matter which may be seen from the base of the brain by pulling the optic commissure slightly backwards. It is continuous in front with the grey matter of the olfactory convolutions of the frontal lobes, and between the latter it is connected to the rostrum of the corpus callosum by the basal white commissure. Laterally, it is continuous with the anterior perforated space. It forms the anterior sloping part of the floor of the third ventricle.

Nerve-tracts in the substance of the thalamencephalon and prosencephalon.—The systems of fibres which are connected with the optic thalamus may be first considered; the principal of these are: (*a*) The posterior commissure; (*b*) the corona radiata of the optic thalamus; and (*c*) the bundle of Vicq d'Azyr.

(*a*) The **posterior commissure** contains a tract of fibres which passes from the optic thalamus to the tegmental region of the mesencephalon on the opposite side; but beyond this, nothing is known with any degree of certainty. It is said to transmit fibres from the fillet and from the posterior longitudinal bundle to the opposite side. Fibres are also said to proceed *viâ* this commissure from the ganglion habenulæ and the pineal body to the oculo-motor nucleus of the opposite side. It is therefore a bundle of decussating fibres derived from various sources, and probably does not contain any true commissural fibres.

(*b*) The **corona radiata of the optic thalamus** is formed of a system of fibres which converge to the thalamus from the cortex of the frontal, parietal, occipital, and temporal lobes, and it also receives a small bundle from the cortical part of the olfactory tract. Portions of this system, namely, the fibres from the occipital lobe (posterior peduncle of the thalamus), and from the temporal lobe (inferior peduncle), require special notice. The **posterior peduncle of the thalamus** (optic radiation) passes backwards in the white matter of the hemisphere in company with a great bundle of sensory fibres to the occipital lobe. It is further described in connection with the optic nerve (page 746). The **inferior peduncle** may, for the sake of simplicity, be described with the ansa peduncularis, as it forms an important constituent of that body.

The **ansa peduncularis** may be exposed from the base of the brain by dissecting the optic tract from the surface of the crus cerebri. It is a band of fibres which winds round the ventral surface of the crusta just at the transition of the latter into the inner capsule. Its principal constituents are the ansa lenticularis and the inferior peduncle of the thalamus. The **ansa lenticularis** proceeds from the medullary laminæ of the lenticular nucleus and passes transversely inwards immediately below the globus pallidus. It then enters the subthalamic region, and without doubt passes into the mesencephalon, but its exact course cannot be followed with certainty. The **inferior peduncle of the thalamus** is partly formed by a sagittally-directed bundle which passes backwards through the substance of the thalamus between the anterior pillar of the fornix and the bundle of Vicq d'Azyr. This bundle is joined by fibres from the superior surface of the thalamus (stratum zonale). The fibres from the stratum zonale pass from the superior to the internal surface of the thalamus, and finally, reaching the inferior surface of that body, join the sagittal bundle first mentioned to form the inferior peduncle; the latter now passes outwards below the ansa lenticularis and ends in the cortex of the temporal lobe.

(*c*) The **bundle of Vicq d'Azyr** passes from the anterior tubercle of the thalamus to the nucleus of the corpus albicans. It might be regarded as a constituent of the corona radiata—the nucleus of the corpus albicans being considered as modified cortex.

The white matter of the cerebral hemispheres contains the following systems of fibres: (*a*) The corona radiata; (*b*) commissural or interhemispheric fibres; (*c*) association or intrahemispheric fibres. These three systems of fibres are disposed in more or less defined tracts which can be unravelled by dissection, but in certain situations where the different tracts cross one another the arrangement becomes more complicated. This is notably the case in the region where the fibres of the corpus callosum intersect the fibres of the inner capsule.

The **corona radiata** is the name given to the prolongation of the fibres of the inner capsule into the hemisphere. It is continued upwards from the inner capsule as a somewhat narrow band (peduncle of the corona radiata), but the fibres soon spread out like a fan and proceed to the cerebral cortex. It will be well at this stage to re-examine the constitution of the inner capsule; the latter contains three sets of fibres, namely: (*a*) Fibres which pass from the crusta of the crus cerebri directly into the corona radiata without the intervention of nerve-cells; (*b*) fibres passing from the mesencephalon into the optic thalamus and corpus striatum; and (*c*) fibres from the thalamus (part of the corona radiata of that body); and from the corpus striatum to the cerebral cortex. We have already seen (page 701) that the inner capsule shows in horizontal section an anterior limb, a posterior limb and a genu. The fibres which occupy the most anterior part of the anterior limb belong to the corona radiata of the optic thalamus. Behind these fibres is a tract which extends nearly to the genu; this tract is formed by fibres which are derived from the frontal lobe, and although their function is not accurately known they are supposed to be associated with the higher intellectual functions. Traced downwards, this bundle passes into the crusta, forming rather more than the inner fifth of that body, and from thence enters the pons, where a part of it seems to terminate (frontal pontine tract). Its further course is unknown. The portion of the inner capsule immediately in front of the genu is intimately associated with the faculty of speech; it passes in the crusta immediately external to the frontal pontine tracts. The genu conveys fibres from the cortex cerebri to some of the motor cranial nerves. These fibres pass immediately external to the preceding (aphasia) bundle, and probably decussate in the pons to become connected to the nuclei of the facial and hypoglossal nerves, and to the motor nucleus of the trigeminal. The anterior two-thirds of the posterior limb of the inner capsule is formed by the pyramidal tract which is described elsewhere (page 741). The posterior third of the posterior limb of the inner capsule is formed by sensory fibres comprising the optic radiation; the latter proceeds exclusively from the occipital lobe. The remaining sensory fibres are derived from the occipital and temporal, and to a certain extent from the parietal, lobes. They descend in the crusta, occupying the outer third of that body. As this sensory tract traverses the crusta, its outermost part is formed by fibres derived from the fillet.

The **commissural system,** consisting of the corpus callosum and the anterior commissure, has been already described (pages 692, 701).

The **intrahemispheric** or **association fibres** unite different portions of the cortex of the same hemisphere to one another. These fibres are in two sets—a long and a short. The **short fibres** (fibræ arcuatæ seu propriæ) unite two adjacent convolutions, the fibres passing round beneath the fissure which separates the two convolutions. The **long fibres** are disposed in several more or less well-defined tracts, namely: the cingulum, the fasciculus arcuatus, the fasciculus uncinatus, the perpendicular occipital fasciculus, and the fasciculus longitudinalis inferior. The **cingulum** is a well-defined band, which occupies the core of the gyrus fornicatus. Near the splenium of the corpus callosum it receives an accession of fibres from the occipital lobe. The **fasciculus arcuatus** passes from the cortex of the frontal to the occipital lobe; it also sends some fibres into the temporal lobe. The **fasciculus uncinatus** springs from the orbital gyri and from the inferior frontal convolution, and, after traversing the lower part of the claustrum, ends in the cortex of the temporal lobe near the amygdaloid nucleus. The **perpendicular occipital fasciculus** passes from the inferior parietal lobule to the inferior occipito-temporal convolution. The **fasciculus longitudinalis inferior** is an extremely well-defined bundle which passes from the occipital to the temporal lobe.

The **external capsule** also belongs to the association system, as it is chiefly concerned with the convolutions of the island of Reil.

Dissection.—The student should remove the pia mater from the anterior part of the upper surface of the cerebellum, and also any of that membrane which may be still adherent to the quadrigeminal bodies. The anterior part of the cerebellum should now be gently pushed backwards until the quadrigeminal bodies and the lateral parts of the crura cerebri are fully exposed. The valve of Vieussens and the slender pair of fourth nerves which spring from its upper part are very liable to injury at this stage. In conducting this dissection, the student will notice a pair of broad white bands, the superior peduncles of the cerebellum, converging towards the lower pair of quadrigeminal bodies, and a thin white lamina, the valve of Vieussens, filling the interspace between them. The mesencephalon is now fully exposed, and its free surface should first be examined. Directions will be subsequently given for the examination of its internal structure.

THE MESENCEPHALON

The **aqueduct of Sylvius** is a narrow passage, a little more than half an inch long, which unites the cavities of the third and fourth ventricles: hence it is sometimes called **iter e tertio ad quartum ventriculum.** It is roofed by a plate of grey matter, the **lamina quadrigemina,** which is surmounted by two pairs of elevations, the **corpora quadrigemina.** Its floor is formed by the tegmenta of the crura cerebri. Its outline in transverse section varies in different parts of its course. Thus, at its commencement, under the posterior commissure, it has the form of an isosceles triangle with the apex directed downwards. Below the anterior quadrigeminal bodies it is heart-shaped, then somewhat shield-shaped. Lower down, on the level of the posterior corpora quadrigemina, it has the form of an ovate leaf with the stalk directed downwards; and finally, at its junction with the fourth ventricle, it is T-shaped in section (fig. 444).

The **grey matter of the aqueduct** is a thick stratum which surrounds that canal, and is continuous with the grey matter of the floor of the fourth ventricle. It is bounded below by the formatio reticularis, and by the posterior longitudinal bundle (fig. 424). It is continuous above with the grey matter of the lamina quadrigemina. Groups of cells are embedded in this grey substance; the most important of these is a long column of nerve-cells which is placed near the middle line beneath the aqueduct close to the formatio reticularis (fig. 424). This is the continuous **nucleus of the third and fourth nerves.** It commences near the junction of the third ventricle and the aqueduct, and extends for nearly the whole length of the latter. It is on a line with the nuclei of two nerves (sixth and twelfth) which arise from the floor of the fourth ventricle. The **nucleus of the descending root of the fifth nerve** is a group of cells in the region of the upper quadrigeminal bodies, situated above and external to the nucleus of the third nerve; it is limited on its outer side by the white fibres of the nerve-root itself.

The **formatio reticularis** will be described with the anatomy of the medulla and pons.

The **CORPORA QUADRIGEMINA** are four greyish elevations which surmount the lamina quadrigemina. The superior or anterior pair are termed the **nates**; the inferior or posterior pair, the **testes.** The corpora quadrigemina are marked off by a cruciform groove, the transverse limb of which is the more distinct. The portion of the vertical groove which lies between the nates is also well marked, but the groove between the testes is shallow and is obscured by a rounded bundle of fibres, the **frenulum veli,** which passes downwards and spreads out on the valve of Vieussens, immediately below the testes. The corpora quadrigemina consist of grey matter overlaid by a thin superficial stratum of white fibres.

The **nates** are broader and darker in colour than the testes, and form a pair of ovoid elevations with their long axes directed upwards and outwards; this direction is continued into the corresponding brachia.

The **brachia of the nates,** or superior brachia, are slightly-raised white bands which pass on each side from the nates in the intervals between the pulvinar of the optic thalami and the corpora geniculata interna. They are sharply marked off from the latter, but less distinctly from the thalami. Each brachium is continued below the corpus geniculatum externum of its own side directly into the optic tract.

The **testes** are lighter in colour, and form more pronounced elevations than the nates. Each testis is a somewhat pear-shaped body, the narrow end of which is continued into the brachium of its own side.

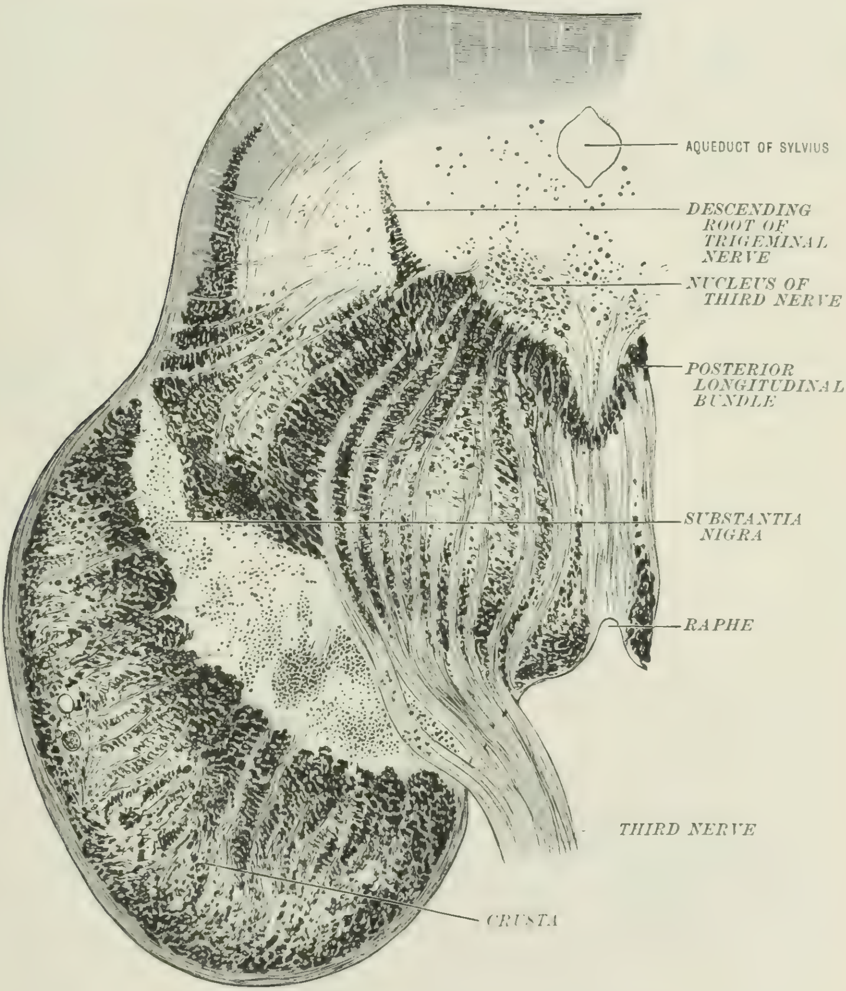
The **brachia of the testes,** or **inferior brachia,** are narrower and more prominent than the brachia of the nates, and run parallel to the latter. Each brachium passes below the corpus geniculatum internum of its own side and disappears from the surface.

The **corpus geniculatum internum** is an oval elevation which is placed behind the lateral groove of the mesencephalon under cover of the pulvinar. Its long axis is directed transversely. A band of white fibres is prolonged from its outer end into the optic tract. This passes as the hindermost layer of fibres in the optic commissure into the corresponding bundle of the opposite side. It is therefore commissural in nature. It does not contribute any fibres to the optic nerve.

The **corpus geniculatum externum** is a slight elevation at the outer side of the pulvinar. It is directly continuous with the optic tract.

The remainder of the mesencephalon is formed by the **crura cerebri**, each of which is divided into three distinct parts easily recognised in transverse section (fig. 424). These are (1) a greyish upper portion, the **tegmen**; (2) a band of almost black substance, the **substantia nigra**; and (3) a lower white portion, the **crusta**, which appears at the base of the brain. The tegmen is also marked off superficially from the crusta by two grooves, the **oculo-motor** and the **lateral groove**, which may be seen in section to correspond with the inner and outer extremities of the substantia nigra. The oculo-motor groove derives its name from the third or oculo-motor nerve, the filaments of which reach the surface along this furrow. The **lateral groove** of the mesencephalon is best marked near the upper border of the pons, where it is bounded below by the superficial fibres of the crusta; and above

FIG. 424.—DEEP ORIGIN OF THE THIRD NERVE. (After Krause)

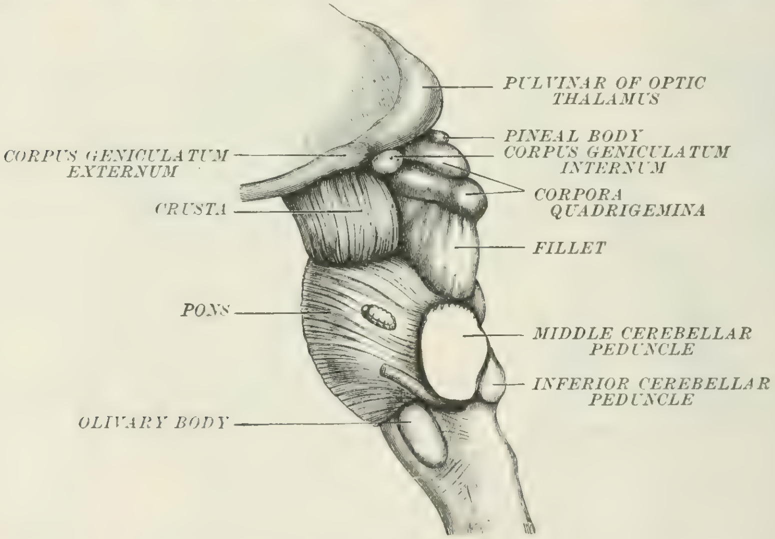


by a triangular band of fibres, the **fillet**, which disappears under the testis and its brachium.

The **crusta**, or **pes**, is a large flattened band of white fibres which is crescentic in section, with the concavity directed backwards and inwards, and in contact with the substantia nigra. Its antero-inferior, inner, and outer surfaces are free. These surfaces are marked with ridges indicating the bundles of fibres of which it is composed. These ridges do not run parallel to the axis of the crus, but take a slightly curved course, passing at first outwards and then upwards. The crusta is continuous below through the pons with the pyramidal body of the same side, and with the cerebellar hemisphere of the opposite side. It is somewhat constricted where it emerges from the pons. It is continuous above with the inner capsule.

Dissection.—The student should scrape away the remains of the lenticular nucleus on the left side until the white substance of the inner capsule is exposed. He should then raise the superficial fibres of the under surface of the crus of the same side, and by tearing off these fibres in an upward direction he may readily demonstrate the continuity of the crusta with the inner capsule. The dissector may also follow the fibres of the crusta downwards to the pyramidal bodies by cutting through the superficial transverse fibres of the pons, but it is better to defer this dissection till a later period. The remainder of the mesencephalon with the optic thalami should be carefully preserved until the end of the dissection of the brain, when they should be examined in connection with the medulla and pons by a series of sections.

FIG. 425.—LATERAL VIEW OF MESENCEPHALON, PONS, AND MEDULLA. (Gegenbaur.)


PULVINAR OF OPTIC THALAMUS
PINEAL BODY
CORPUS GENICULATUM EXTERNUM
CORPUS GENICULATUM INTERNUM
CORPORA QUADRIGEMINA
CRUSTA
FILLET
PONS
MIDDLE CEREBELLAR PEDUNCLE
INFERIOR CEREBELLAR PEDUNCLE
OLIVARY BODY

The fibres composing the **central third** of the crusta are derived from the pyramidal bodies and pass into the anterior half of the posterior limb of the inner capsule to the ascending frontal and ascending parietal convolutions. Its **outer third** is formed by fibres which are partly derived from the cerebellar hemispheres of the opposite side, and which pass through the posterior half of the posterior limb of the inner capsule to the temporal and occipital lobes. These fibres are considered to be sensory in function. Lastly, the fibres constituting its **inner third** pass upwards through the genu and anterior limb of the capsule to the convolutions of the frontal lobe, while below some form communications with the nuclei of the cranial nerves, and others are distributed to the cerebellum in a similar manner to the fibres of the outer third of the crusta. There are other tracts of minor importance in the crusta.

The **tegmental portions** of the crura cerebri, unlike the crustæ, are continuous with one another across the middle line, where they unite in a median raphe. Each tegmen extends into the thalamencephalon below the optic thalamus, where it contains a yellowish-grey lenticular body which is called the **subthalamic body.** The tegmentum contains both grey and white matter, with a continuation of the formatio reticularis of the medulla and pons. The most conspicuous of the collections of grey matter is the **tegmental** or **red nucleus**, a mass of brownish-grey matter which is placed below the optic thalamus, and extends backwards into the mesencephalon below the aqueduct. It appears round in coronal sections (fig. 423).

The best marked of the white strands are the superior peduncles of the cerebellum, the fillet, and the posterior longitudinal bundle (fig. 444). The filaments of origin of the third nerve, passing from its nucleus through the tegmentum and inner part of the substantia nigra, are also conspicuous in sections (fig. 443).

The **superior cerebellar peduncle** is readily distinguishable in sections through the lowest part of the mesencephalon as a white, crescent-shaped bundle with its inner or concave side bounded by the grey-coloured formatio reticularis which separates it from the grey matter of the aqueduct. Higher up it takes a deeper course below the floor of the aqueduct, and decussates with its fellow of the opposite side. It then passes into the subthalamic region, and separates into an inner and an outer division. The inner division passes internal to the red nucleus and enters the under surface of the optic thalamus. The outer division passes external to the red nucleus and probably enters the globus pallidus of the lenticular nucleus. Fibres have been described as passing from the red nucleus to the cerebral cortex.

The **fillet** appears at the level of the lower quadrigeminate bodies as a flat band of longitudinal fibres in the ventral part of the tegmentum, into which it has passed from the pons (fig. 429) and dorsal to the substantia nigra. It consists of three parts, an outer or lateral, internal or mesial, and an intermediate or middle part. The lateral part passes outwards to the surface and curving round the outer side of the superior cerebellar peduncle it terminates at the lower quadrigeminate body (fig. 425). It is also known as the lower fillet, and in addition to fibres derived from the ascending antero-lateral tract by the superior medullary velum it contains fibres from the opposite auditory nucleus, and other fibres which have passed from the nuclei of the fasciculus gracilis and fasciculus cuneatus of the opposite side by the superior pyramidal decussation. The internal or mesial fillet turns downwards into the inner part of the crusta and is continued to the subthalamic tegmental region, where it enters the ansa lenticularis, by which it is conveyed to the medullary laminæ of the lenticular nucleus. The middle or intermediate fillet is separable into two parts: an outer part, called the upper fillet, which terminates in the white matter of the superior quadrigeminate body, and a remaining portion which passes upwards into the subthalamic tegmental region, and possibly reaches the brain cortex. The fibres of the middle fillet are derived from the antero-lateral column of the cord of the same side, from the nuclei of the funiculus gracilis and the funiculus cuneatus of the opposite side by the superior pyramidal decussation, and from the cerebellum.

The **posterior longitudinal bundle** is a strand of large white fibres which lies directly beneath the ventral part of the central grey matter of the aqueduct in the lower part of the mid-brain, whilst in the upper part it gains a more lateral position (fig. 424); it can be traced downwards to the pons (fig. 429) and medulla, and upwards to the posterior commissure, the pineal body, and the subthalamic region. It is a commissural strand which connects the cerebellum with the nuclei of the cranial nerves, and it also associates the various cranial nuclei together. It is particularly connected with the third and sixth cranial nuclei of opposite sides, some of the fibres decussating through the raphe, and it possibly contains fibres which have passed upwards from the antero-lateral columns of the spinal cord.

The Epencephalon

Dissection.—The pia mater should be removed from the superior and inferior surfaces of the cerebellum; care should be taken, however, in removing it from the inferior vermiform process. In dissecting the latter region, the membranes should be clipped close with scissors rather than pulled out, as by the latter method the choroid plexuses of the fourth ventricle would be removed and the fragile posterior medullary velum would be torn. The student should examine first the upper and then the lower surface of the cerebellum, but he should defer the study of the anterior parts of the inferior vermiform process (pyramid and nodule) until the fourth ventricle is opened.

The **CEREBELLUM** consists of two lateral masses, the hemispheres, which are united by a narrower median portion, the vermiform process. This is seen in sagittal section in fig. 427. This median portion is but slightly raised above the level of the hemispheres as seen from above, where it constitutes the **superior vermiform process** (fig. 427); but, as seen from below (**inferior vermiform process**), it forms the roof of a deep recess between the hemispheres, the **vallecula**, which is occupied for the most part by the medulla. The vallecula terminates in front at the cavity of the fourth ventricle. Behind, it passes into a deep notch, the **incisura marsupialis**, which is occupied by the falx cerebelli and the cisterna magna of the subarachnoid space. The surface of the cerebellum is covered by a number of **folia**, which are curved, with a general direction convex backwards and outwards. The folia are much narrower than the cerebral convolutions, and are of a darker grey color than the latter. They are separated by **fissures**, some of which appear on the surface separating individual folia; others dip in for some distance below the surface, and within these secondary fissures are developed. In this way the great horizontal fissure and the interlobar fissures are formed. The separation into lobes is somewhat arbitrary, as fissures resembling the interlobar fissures in character traverse the substance of the lobes.

The cerebellum is connected to the adjacent parts of the cerebro-spinal axis by three pairs of **peduncles**: a **superior** pair to the cerebrum; a **middle** pair to the pons; and an **inferior** pair to the medulla.

The **great horizontal fissure** is deeper than the interlobar fissures. It commences at the point where the middle peduncle of the cerebellum enters the hemisphere and pursues a curved course around the margin of the hemisphere, inclining first downwards, and then curving slightly upwards, and crossing the middle line immediately above the incisura marsupialis, to pursue a similar course on the opposite side. On opening up the fissure, numerous folia are seen to run obliquely within it, some of which cross the floor of the fissure so as to connect the upper and lower surfaces which bound the fissure. The great horizontal fissure separates the superior and inferior surfaces of the cerebellum.

The **superior surface of the cerebellum** has a general inclination backwards and outwards. This surface is approximately flat, but shows a slight concavity corresponding to the superjacent occipital lobe of the cerebrum. Mesially the slope of the surface becomes more abrupt, and forms the **superior vermiform process.** Of the fissures which traverse this surface the most important is the **sulcus cerebelli superior,** which branches off from the great horizontal fissure at its commencement and curves over the posterior part of the upper surface to approach the great horizontal fissure again at the superior vermiform process, where the two fissures are separated only by a narrow band, the folium cacuminis (fig. 427). The sulcus cerebelli superior divides the superior surface into a larger anterior part, the **quadrate lobe,** and a smaller semilunar posterior portion, the **posterior superior lobe.** Another fissure divides the quadrate lobe into an **anterior crescentic** and a **posterior crescentic portion.** The anterior crescentic portion is usually subdivided into two portions by another sulcus parallel to the fissure last mentioned.

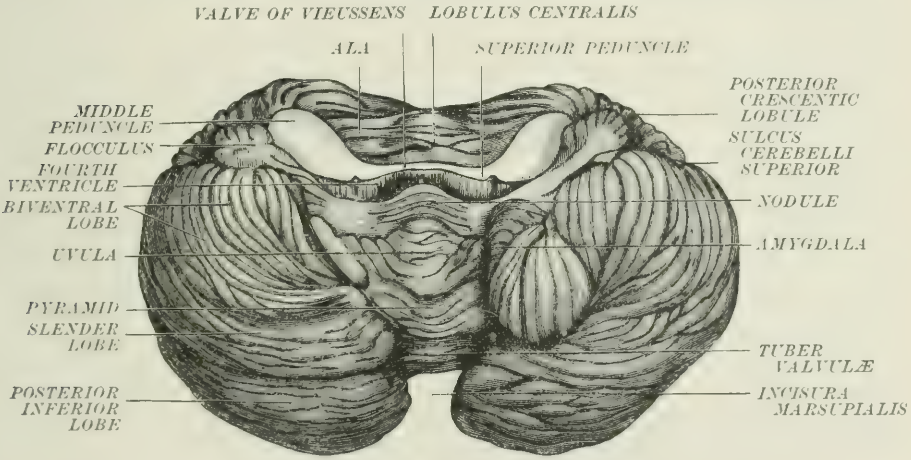
The **superior vermiform process** is divided by fissures, continuous with the sulci above described, into parts which are placed in the following order from before backwards: lobulus centralis, monticulus cerebelli, and folium cacuminis. The **lobulus centralis** is a small squarish mass which is placed below and behind the testes, separated from the latter by a fold of pia mater. It rests below on the lingula, which separates it from the valve of Vieussens (fig. 426). It expands laterally into a pair of somewhat triangular folds, the **alæ** (fig. 426), which are entirely overlapped and hidden by the quadrate lobes when the cerebellum is viewed from above in its undisturbed position. The **lingula** is a small tongue-shaped portion of the cerebellum which lies on, and is adherent to, the valve of Vieussens. Its basal part is continuous with the lobulus centralis, and it consists of from four to five transverse folia. The **monticulus cerebelli** is divided into an anterior elevated portion, the culmen, and a posterior sloping part, the declive. The **culmen** connects the anterior crescentic portions of the quadrate lobes of opposite sides, and is traversed by the fissures which intersect these portions. The **declive** connects the posterior crescentic portions, and consists of about six or seven transverse folia. The **folium cacuminis** is a narrow band which connects the posterior superior lobes of opposite sides. It is not a simple folium, but is marked on its superior and inferior surfaces by transverse furrows.

The **inferior surface of the cerebellum** shows a pronounced convexity corresponding to the inferior fossæ of the occipital bone on which it rests. It is smoothly rounded off externally and behind, but changes its direction abruptly internally and in front, where it comes in contact with the medulla and pons. It is marked off into lobes, which are arranged in the following order from behind forwards: posterior inferior, slender, biventral, tonsillar, and flocculus. The **posterior inferior** is a narrow crescentic lobe, which bounds the great horizontal fissure inferiorly. The **slender** (**lobulus gracilis**) is similar in shape, but narrower, as its name implies. The **biventral,** shorter and thicker than the two last described, is divided by a well-marked fissure into an anterior and a posterior portion. The **tonsillar lobe** (**amygdala**) lies internal and slightly anterior to the biventral, and is partly hidden in the vallecula. The **flocculus** is a small lobe forming a marked projection in front of the biventral lobe, which it separates from the middle peduncle of the cerebellum.

The **inferior vermiform process** is formed by the following parts, taken in order from behind forwards: tuber valvulæ, pyramid, uvula, and nodule. The **tuber valvulæ** is a transverse band, consisting of about seven or eight folia, which connects the posterior inferior and slender lobes with their fellows of the opposite side. The **pyramid** is the most massive portion of the inferior vermiform process, and is connected to the biventral lobes on each side. It consists of from five to eight folia. The **uvula** is an elongated portion, compressed laterally, and connected to the amygdala on each side by the **furrowed band.** The **nodule,** or **laminated tubercle,** is the prominent anterior extremity of the inferior vermiform process which projects into the cavity of the fourth ventricle. It is connected to the flocculus on each side by a thin white plate, the **inferior medullary velum.** The latter will be referred to in connection with the anatomy of the fourth ventricle.

Fig. 426.—Inferior Surface of the Cerebellum.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)



Dissection.—The student should now obtain a view of the principal systems of fibres in the cerebellum by the following dissection, which we shall speak of as Reil's method. The great horizontal fissure should be opened up and the portion of the cerebellum which lies superior to that fissure gently torn off the underlying portion. If this proceeding has been successfully accomplished, a large **bundle of fibres** will be seen passing through a **gap** between the superior and middle peduncles of the cerebellum, and passing towards the superior surface. This bundle is formed by the restiform body and by the lower fibres of the pons. The position of the corpus dentatum will also be noticeable near the middle line, as the white fibres which form the capsule of that body are disposed in ridges corresponding to the plications of grey matter of the nucleus. A more superficial dissection on the opposite side will show the fibres of the abovementioned bundle passing inwards, forming at first curves convex backwards, and then sweeping upwards into the folia of the superior vermis. A horizontal section through the corpus dentatum on the right side will expose the plicated bag of grey matter which constitutes the nucleus, an opening into which, the hilum, will be seen on the inner and upper side. If a small portion of the fibres of the superior peduncle of the cerebellum of the same side be now raised and torn gently in a downward direction, the fibres are readily traceable into the white centre of the nucleus.

A horizontal section through the superior vermis will show the smaller nuclei of the cerebellum (nuclei fastigii, emboliformis, and globosus). These are, however, somewhat difficult to find. Lastly, a median sagittal section will expose the fourth ventricle, to obtain a good view of which the remainders of the cerebellar hemispheres should be drawn gently aside. In doing this care should be taken of the inferior medullary velum.

White matter of the cerebellum.—In a mesial sagittal section of the cerebellum (fig. 427) the amount of white matter is smaller in proportion to the grey matter than in any other section. It presents a characteristically branched appearance which is called the **arbor vitæ.** Two main divisions, the vertical and horizontal branches, of the arbor vitæ are described, and from these secondary ramifications arise. The **vertical branch** is mainly continued into the culmen, where it subdivides somewhat freely. It sends forwards usually two branches into the lobulus centralis, and a slender twig into the lingula. The main axis of the horizontal branch is prolonged into a slender white band, which enters the folium cacuminis. From the upper surface of the **horizontal branch** a stout offset is sent into the declive, and from its lower surface branches are sent into the tuber valvulæ, pyramid, and uvula. A small offset enters the nodule, and if this be traced in a lateral direction it will be found to be continued into the inferior medullary velum.

In coronal sections the disposition of the white matter in the hemispheres is well seen. It forms a somewhat ovoid mass in each hemisphere, near the centre of which the corpus dentatum is placed (fig. 416). The appearance is very similar in sagittal sections through the centre of a hemisphere. It is not necessary to give a separate description of the divisions of the white matter, as these correspond to the lobulation of the surface.

The **grey matter in the interior of the cerebellum** consists of four pairs of nuclei, which are everywhere separated by white matter from the grey matter of the folia. The largest of these nuclei in each hemisphere is called the corpus dentatum. The smaller, which are placed nearer the middle line, are called the nucleus emboliformis, nucleus globosus, and nucleus fastigii.

The **corpus dentatum** is a crumpled sheet of grey matter which presents a similar outline in coronal, sagittal, and horizontal sections. This outline is approximately an oval bounded by a wavy line. This line is broken only on the inner and anterior side, where the white matter of the exterior is continuous with that of the interior through an aperture called the hilum.

The **nucleus emboliformis** is an elongated streak of grey matter, which is placed on the inner side of the corpus dentatum. It is somewhat enlarged at its anterior extremity, hence it may be described as club-shaped. The **nucleus globosus** consists of several spheroidal clumps of grey matter, which are placed on the inner side of the preceding; these clumps are connected with one another, and also with the nucleus emboliformis and nucleus fastigii. The **nucleus fastigii** varies somewhat in its minute structure from the three nuclei above described. It is situated immediately over the roof of the fourth ventricle, separated from that cavity, however, by a thin stratum of white matter. The nuclei of opposite sides nearly touch one another in the middle line.

The **fibres of the cerebellum** may be described under the following heads: (*a*) Fibres derived from the cerebellar peduncles, and (*b*) intrinsic fibres. (*a*) The fibres of the middle peduncle connect the cerebellum (1) with the nuclei of the pons on the same side, (2) with the posterior longitudinal bundle and the fillet of the same side, and by means of these tracts with the corpora quadrigemina, and the antero-lateral tract of the spinal cord, (3) with the pyramidal tracts of the same and the opposite side by means of which connections are established with the corpora quadrigemina and the corpus striatum. The **upper fibres of the pons** pass into the lateral parts of the cerebellar hemispheres, and end in the grey cortex. The **middle fibres** sweep downwards, forming the oblique fasciculus, and end in the folia of the inferior surface. The **lower fibres** accompany the restiform body to the superior surface. The **restiform body** (inferior peduncle) is joined on entering the cerebellum by the inferior fibres of the pons; the two together unite into a distinct round bundle, the inner part of which is formed by the restiform body; the outer by the pons-fibres. This bundle passes through a distinct gap or interval bounded by the superior peduncle internally, and by the greater part of the middle peduncle externally. Its fibres then spread out into a layer, the fibræ semicirculares of Stilling which are disposed in gentle curves convex backwards and outwards; these fibres cover the capsule of the corpus dentatum, and finally sweep abruptly upwards into the folia of the superior vermis. Some fibres enter the nucleus fastigii. The fibres of the inferior peduncle are connected with the opposite olivary body, with the fillet and posterior longitudinal bundle of the same side, and with the antero-lateral column of the cord.

The corpus dentatum is covered by a distinct capsule of fibres (the 'fleece' of Stilling) derived from the olivary nucleus of the opposite side. The fibres are probably for the most part interrupted in the nerve-cells of the corpus dentatum, and are then (indirectly) continued into the white matter which occupies the interior of that plicated bag of grey matter. From the hilum of the corpus dentatum a bundle of fibres passes out, which is joined by fibres from the fleece, and thus the **superior cerebellar peduncle** is formed. The superior cerebellar peduncle passes upwards and inwards, and receives a covering on its outer side from the inferior fillet. It disappears from the surface by passing under cover of the testis of its own side, and assumes a deeper position in the mesencephalon, passing to the ventral side of the aqueduct of Sylvius. The majority of the fibres decussate with their fellows of the opposite side, the decussation being most pronounced at the level of the centre of the nates. The decussation being completed, the decussated fibres and those which remain on the same side proceed brainwards as a distinct column. This column of fibres soon encounters the red nucleus, and the fibres pass through the nucleus in small bundles, the cross-section of which gives the punctated appearance to the red nucleus which is so characteristic of that body when seen in coronal section. Beyond the red nucleus, fibres of the superior peduncles certainly enter the optic thalamus, and probably the globus pallidus and the cortex cerebri.

(*b*) Sagittally-directed fibres are placed within the superior vermis. When traced forwards these fibres are found to decussate with their fellows of the opposite side in front and above the nucleus fastigii; here they are joined by true commissural fibres from its hemispheres, the whole forming the **great anterior cerebellar commissure** of Stilling.

Fibres unite the different folia to one another, constituting a system of fibres which form the most peripheral part of the arbor vitæ. These fibres, from their general arrangement, are called **garland-like fasciculi.**

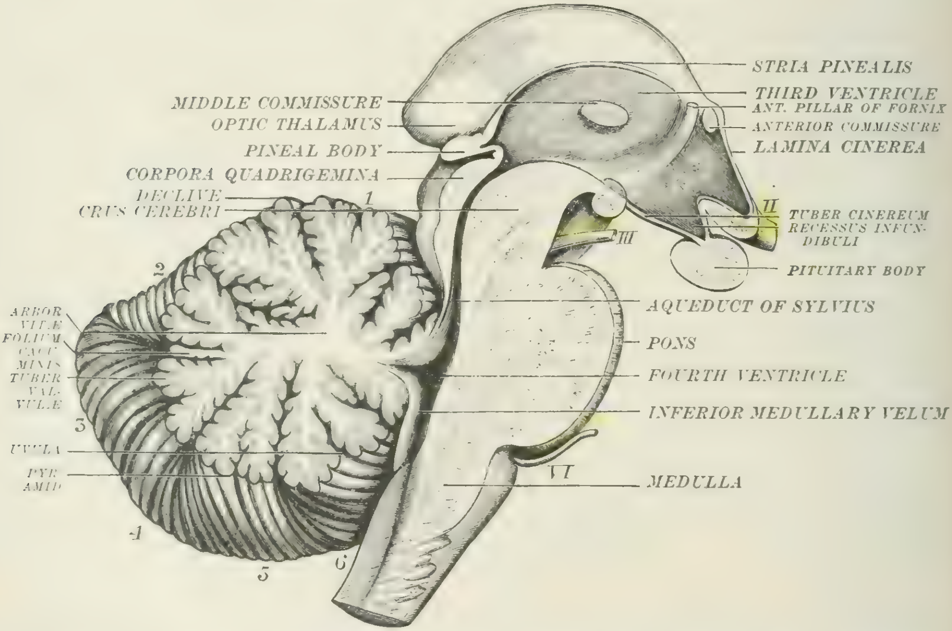
The **FOURTH VENTRICLE** is a cavity which is widest and most lofty about its centre, and narrowed at its anterior and posterior extremities. It communicates with the third ventricle above through the aqueduct of Sylvius, and passes below into the central canal of the spinal cord. Its long axis is directed upwards and forwards. The structures which bound it behind are said to constitute its roof, while the parts bounding it in front are described as its floor. The **roof** is formed from above downwards by the following structures: the superior peduncles of the cerebellum with the valve of Vieussens between them, the white matter of the vermiform process of the cerebellum, the inferior medullary vela, and the epithelial lining of the choroid plexuses and tela choroidea inferior. Some small plates of white matter, the obex and the ligulæ, also enter into the formation of the roof. The inferior part of the **floor** is formed by the medulla and the superior part by the posterior surface of the pons. Some white lines (striæ acusticæ), which cross the floor transversely, approximately separate the pontine from the medullary portion of the floor.

The **valve of Vieussens,** or **superior medullary velum,** is a thin plate of white matter which fills in the angular interval between the superior peduncles of the cerebellum. It is continuous behind with the white matter of the superior vermiform process of the cerebellum. The lingula rests on the posterior part of its upper surface. The fibres of the fourth nerve decussate within its substance at its upper part.

The **inferior medullary vela** are thin crescentic translucent bands of white matter which extend from the nodule to the flocculus on each side; hence they have been called **commissuræ ad flocculos.** Each velum presents a concave edge, which is apparently free, but which is in reality continued into the epithelium, which covers the choroid plexuses. It is attached to the cerebellum by its convex edge.

The **choroid plexuses** of the fourth ventricle are convoluted vascular folds of the pia mater, which project into the cavity of the fourth ventricle, but are excluded from the ventricular cavity by a layer of epithelium. They run at first forwards close together on each side of the middle line, and then turn outwards along the edges of the inferior medullary vela to reach the lateral recesses of the ventricle, where they become continuous with the general pia mater.

FIG. 427.—RIGHT HALF OF THE ENCEPHALIC PEDUNCLE AS SEEN FROM THE INSIDE OF A MEDIAN SECTION. (Allen Thomson, after Reichert.)


STRIA PINEALIS
THIRD VENTRICLE
ANT. PILLAR OF FORNIX
ANTERIOR COMMISSURE
LAMINA CINEREA
MIDDLE COMMISSURE
OPTIC THALAMUS
PINEAL BODY
CORPORA QUADRIGEMINA
DECLIVE
CRUS CEREBRI
1
II
TUBER CINEREUM
RECESSUS INFUNDIBULI
III
PITUITARY BODY
2
ARBOR VITÆ
FOLIUM CACUMINIS
TUBER VALVULÆ
AQUEDUCT OF SYLVIUS
PONS
FOURTH VENTRICLE
INFERIOR MEDULLARY VELUM
3
UVULA
PYRAMID
VI
MEDULLA
4
5
6

1, culmen ; 2, posterior crescentic lobe ; 3, posterior inferior lobe ; 4, slender lobe ; 5, biventral lobe ; 6, amygdala.

The **tela choroidea inferior** is a layer of pia mater which closes in the lower and back part of the fourth ventricle. It extends from the choroid plexuses to the ligulæ and obex, where it is continued into the pia mater which covers the posterior surface of the lower part of the medulla. As already mentioned in the description of the meninges, it presents three openings or deficiencies: one (**foramen of Majendie**) in the middle line immediately above the obex, and two (**foramina of Key and Retzius**) at the lateral recesses.

The **obex** is a thin, somewhat triangular plate of white matter, occupying the angular interval between the two diverging clavæ. It is not infrequently absent.

The **ligulæ** are thin narrow strips of white matter, which project from the inner margins of the clavæ. They run at first upwards and forwards, and then turn outwards around the restiform bodies. They may sometimes be traced as far as the flocculi, when they become continuous with the inferior medullary vela. Their inner, apparently free, edges are continuous with the epithelial roof of the fourth ventricle.

The **floor of the fourth ventricle** is a depressed area, which is rhomboidal in outline, the longer diameter of the rhomboid being directed upwards and forwards and marked by a very distinct fissure, the **sulcus longitudinalis medianus,** which is continuous below with the central canal of the spinal cord. The ventricular floor is bounded laterally by the clavæ and corpora restiformia below, by the middle peduncles of the cerebellum in the middle, and by the superior peduncles of the cerebellum above. Under cover of the obex, where the fourth ventricle is about to join the central canal of the cord, a small ampulla is formed, termed the **ventricle of Arantius.** The widest part of the floor corresponds to the lateral recesses of the ventricle. Close behind the lateral recesses, the floor is crossed by some white lines, the **striæ medullares** or **striæ acusticæ,** which emerge from the sulcus longitudinalis medianus, and pass outwards to the auditory nerve. The striæ divide the floor into two approximately equal parts, an inferior and a superior.

The **inferior moiety of the floor** is indented by an angular groove, the **fovea inferior** or **posterior,** which marks off a depressed triangular area of a grey colour, the **ala cinerea.** The latter corresponds in position to the subjacent nuclei of the vagus and glosso-pharyngeal nerves, and is therefore also termed the **trigonum vagi.** The apex of the posterior fovea is directed forwards. It nearly touches the striæ acusticæ, and thus two other triangular areas, both of a whitish colour, are marked off in the inferior moiety of the floor. The internal of these areas is called the **trigonum hypoglossi,** since it corresponds in position to the nucleus of the hypoglossal nerve. It is bounded by the inferior fovea, the striæ acusticæ, and the sulcus longitudinalis medianus. The outer triangle is bounded by the inferior fovea, by the striæ acusticæ, and by the clavæ. It forms the inferior part of a prominence or swelling which extends into the pontine portion of the floor. This prominence is called the **tuberculum acusticum.** It is well marked in the brain of the infant.

The **superior moiety of the floor** is completely covered by a thin layer of white substance. It presents, on each side of the sulcus longitudinalis medianus, a semi-cylindrical elevation about five millimetres in length, which is called the **eminentia teres.** It is caused by an underlying bundle of fibres, the **fasciculus teres,** which is now known to be a part of the intrapontine course of the fibres of the facial nerve, though possibly it may contain fibres from other sources. External to the eminentia teres is a depressed area, the **fovea superior,** which is occasionally crossed by a whitish band of fibres, the **conductor sonorus.** The conductor sonorus meets the stria medullaris of its own side, at the sulcus longitudinalis medianus, at an acute angle. Immediately in front of the fovea superior is a bluish spot, the **locus cæruleus,** which is caused by the substantia ferruginea showing through the white covering of the floor. The **substantia ferruginea** is an aggregation of darkly-pigmented cells, which is very conspicuous in transverse sections through the upper part of the floor of the fourth ventricle and through the lower part of the aqueduct of Sylvius.

The **PONS VAROLII** is that portion of the epencephalon which lies in front of the proximal part of the fourth ventricle. As seen from the base of the brain, it forms a considerable prominence, which narrows on each side as it passes into the middle cerebral peduncles. At its lower border the pyramidal bodies are seen disappearing into its substance, while at its upper border the crura cerebri are seen emerging. It rests on the body of the sphenoid bone, reaching upwards as far as the margin of the dorsum sellæ. It presents a ventral and a dorsal surface, and a superior and an inferior border. Lateral surfaces have also been described, but these are determined artificially by dividing the pons proper from the middle cerebellar peduncles. The boundary between the pons and the middle cerebellar peduncles on each side is arbitrarily mapped out by a line drawn from the exit of the trigeminal nerve to the superficial origin of the facial. (Henle.)

The **dorsal surface** has been described in connection with the floor of the fourth ventricle.

The **ventral surface** is broad and prominent, strongly convex from side to side, and slightly convex from before backwards. It presents a transverse striation, corresponding to the bundles of commissural fibres passing from hemisphere to hemisphere of the cerebellum. Mesially, it is marked by a sagittal groove or furrow, which usually lodges the basilar artery, but is in no way caused by the contact with the vessel. On each side of the groove a prominence is formed, where the sagittally-directed fibres of the pyramidal bodies pass brainwards, under cover of the transverse fibres of the pons.

The **superior border** is convex forwards. Its fibres pass directly into the upper border of the middle peduncle of the cerebellum.

The **inferior border** is marked off by a distinct transverse groove from the medulla. It is formed in its inner part by the lowest fibres of the pons, but these are crossed near the junction of pons and middle peduncle by the oblique fasciculus. The **oblique fasciculus** is formed by the middle transverse fibres of the pons, which pass downwards and backwards, internal to the exit of the trigeminal nerve, on each side, and cross the inferior fibres on their superficial aspect.

Coronal sections through the pons (fig. 429) show that it comprises two very distinct regions—an anterior or ventral region and a dorsal region, which is called tegmental, as most of its constituents are continued into the tegmentum of the mesencephalon. The **ventral region** consists of transverse and longitudinal fibres, interspersed with small aggregations of grey matter. The **transverse fibres** are:—(*a*) Fibres which pass from the middle peduncle to the opposite side, where they turn upwards to the brain or downwards to the cord; (*b*) fibres which emerge from the cerebellum by the middle peduncles, and terminate in connection with the nuclei of the pons on the same side. The **longitudinal fibres** are the upward continuation of the pyramids. They pass upwards in flattened bundles, separated from one another by some of the transverse fibres of the pons.

In the **upper** or **tegmental region** the chief things to be observed are: the tract of the fillet (which lies next to the ventral region), the formatio reticularis, the posterior longitudinal bundle, the substantia ferruginea, and the funiculus teres. The superior olivary nucleus, the nuclei of the sixth and seventh cranial nerves, the motor nucleus of the trigeminal, with parts of the ascending and descending roots of the last-named nerve and portions of the nucleus of the auditory nerve, are embedded in this region of the pons (figs. 429 and 430).

The dorsal and ventral parts of the pons are separated by a transverse layer of fibres called the **trapezium** or **corpus trapezoides** (fig. 430), because in some mammals it appears on the ventral surface of the pons in a quadrilateral area between the bundles of the pyramidal fibres of the two sides. It consists of fibres crossing from side to side through the raphe many of which, derived from the accessory auditory nucleus, pass through the trapezium to the lateral fillet of the opposite side and by it are conveyed to the lower quadrigeminate body.

Some of the structures mentioned in the preceding paragraph are visible to the unaided eye in ordinary dissecting-room specimens. The nuclei of the cranial nerves will not be further described here, as a full account of them will be given in the section on the cranial nerves.

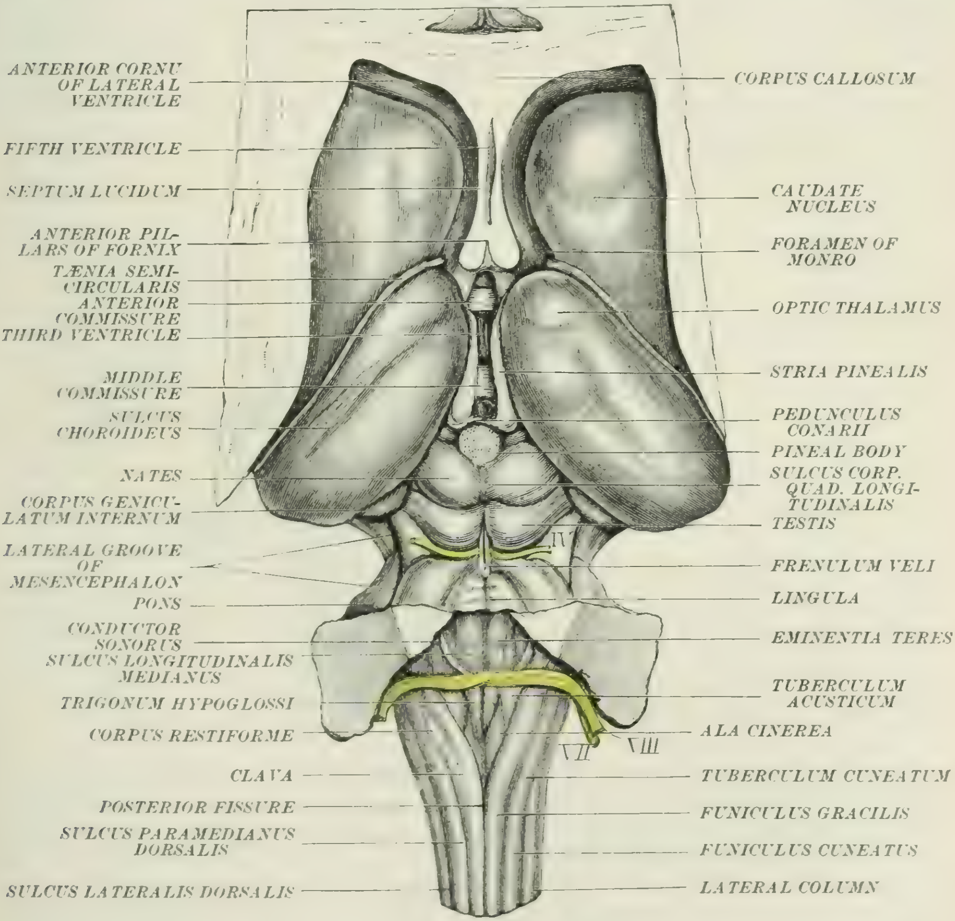
THE METENCEPHALON

The **MEDULLA OBLONGATA**, or **bulb**, is the portion of the cerebro-spinal axis which extends from the inferior border of the pons to the decussation of the pyramids. It presents an anterior, a posterior, and two lateral surfaces. The **anterior surface** rests upon the basilar groove of the occipital bone, and extends downwards as far as the point where the odontoid process is crossed by the transverse ligament of the atlas (Testut). The bulb has the form of a truncated cone, the base of which is continued into the pons above, while the truncated apex is prolonged into the spinal cord below. The **posterior surface** is received into the vallecula, between the cerebellar hemispheres, and forms, by its upper part, as already described, the lower part of the floor of the fourth ventricle. The ninth to the twelfth nerves (with the exception of the spinal part of the spinal accessory) take their superficial origin from its sides. The sixth, seventh, and eighth nerves appear in the transverse groove between the medulla and the pons in numerical order from within outwards.

The **ventricular part** of the medulla has been already described; but on the extraventricular portion certain fissures, and the elevated portions which these fissures map out, require notice.

Fissures.—Commencing in front, we find the **anterior fissure** (fissura longitudinalis anterior) occupying the middle line. It is shallow below, where it is almost separated from the anterior longitudinal fissure of the cord by the decussation of the pyramids; deeper above, where it separates the pyramids of opposite sides. Superiorly, it ends in a blind recess, under the margin of the pons, the **foramen cæcum posterius, or foramen cæcum of Vicq d'Azyr.** External to the anterior fissure, we find the **sulcus lateralis ventralis**; the latter intervenes between the pyramid and the olive above, and extends downwards immediately in front of the olive and the lateral column. It is joined below the olive by the **post-olivary sulcus.** From its upper part, a fissure (**sulcus parapyramidalis**) passes downwards and inwards to join the anterior fissure.

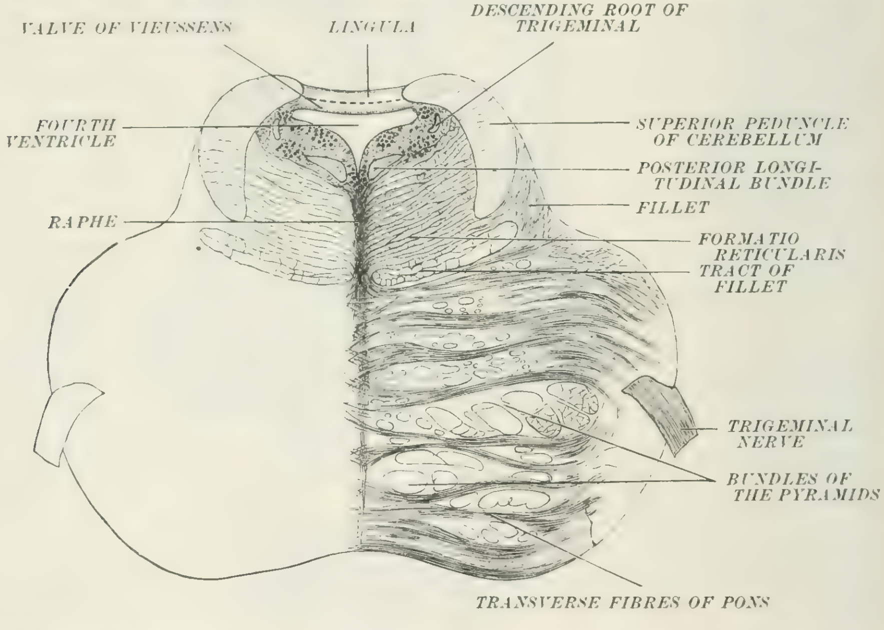
FIG. 428.—METENCEPHALON, MESENCEPHALON, AND THALAMENCEPHALON, FROM THE DORSAL SURFACE. (After Obersteiner.)


ANTERIOR CORNU OF LATERAL VENTRICLE
FIFTH VENTRICLE
SEPTUM LUCIDUM
ANTERIOR PILLARS OF FORNIX
TÆNIA SEMICIRCULARIS
ANTERIOR COMMISSURE
THIRD VENTRICLE
MIDDLE COMMISSURE
SULCUS CHOROIDEUS
NATES
CORPUS GENICULATUM INTERNUM
LATERAL GROOVE OF MESENCEPHALON
PONS
CONDUCTOR SONORUS
SULCUS LONGITUDINALIS MEDIANUS
TRIGONUM HYPOGLOSSI
CORPUS RESTIFORME
CLAVA
POSTERIOR FISSURE
SULCUS PARAMEDIANUS DORSALIS
SULCUS LATERALIS DORSALIS
CORPUS CALLOSUM
CAUDATE NUCLEUS
FORAMEN OF MONRO
OPTIC THALAMUS
STRIA PINEALIS
PEDUNCULUS CONARII
PINEAL BODY
SULCUS CORP. QUAD. LONGITUDINALIS
TESTIS
IV
FRENULUM VELI
LINGULA
EMINENTIA TERES
TUBERCULUM ACUSTICUM
ALA CINEREA
VII
VIII
TUBERCULUM CUNEATUM
FUNICULUS GRACILIS
FUNICULUS CUNEATUS
LATERAL COLUMN

On the **posterior surface** of the medulla we find the **posterior fissure** (fissura longitudinalis posterior) occupying the middle line. It is continuous below with the posterior fissure of the spinal cord, and ends above at the fourth ventricle. External to this we find the **sulcus paramedianus dorsalis,** and more externally the **sulcus lateralis dorsalis.** The former of these two fissures ends above at the apex of the clava, the latter extends for some distance further upwards. To recapitulate, the fissures of the medulla, taken in order from before backwards, are as follows: fissura longitudinalis anterior, sulcus parapyramidalis, sulcus lateralis ventralis, sulcus postolivaris, sulcus lateralis dorsalis, sulcus paramedianus dorsalis, fissura longitudinalis posterior. As will be seen from the previous description, however, this summary applies only to the upper or proximal part of the medulla; in the distal part the fissures become reduced in number owing to some of them becoming confluent with others. Certain of the above-mentioned fissures divide the medulla into columns or areas corresponding, for the most part, to the columns of the cord. Thus we have an anterior area between the anterior fissure and the sulcus lateralis ventralis, a lateral area between the last-named fissure and the sulcus lateralis dorsalis, and a posterior area between the sulcus lateralis dorsalis and the posterior fissure.

The **anterior area** of the medulla is occupied, for the greater part of its extent, by the **pyramidal bodies.** These are a pair of prominences somewhat pyriform in outline, which lie on each side of the anterior median fissure. Their larger ends are directed upwards and abut against the pons where they become slightly constricted. Laterally, they are marked off by the sulci parapyramidales. Their apices are directed downwards and correspond to the decussation of the pyramids. The greater number of the fibres pass across at this point and make their way into the lateral column of the opposite side of the cord (lateral pyramidal tract); a small bundle, however, of the outermost fibres of each pyramid runs downwards in the anterior column of the cord of the same side (anterior pyramidal tract).

FIG. 429.—TRANSVERSE SECTION THROUGH THE UPPER PART OF THE PONS. (Schwalbe.)



The remainder of the anterior column is occupied by the **funiculus anterior.** This is a triangular area of white substance which intervenes between the sulcus parapyramidalis and the sulcus lateralis ventralis. Its base is directed downwards, and is continuous with the anterior ground bundle of the anterior column of the cord. Its apex, directed upwards, is wedged in between the olivary and pyramidal bodies. The progressive diminution of the tract when traced upwards is owing to its fibres receding from the surface, being overlapped by the pyramidal body.

The **lateral area** of the medulla is narrow below, being formed by the continuation of a portion only of the lateral column of the cord. Higher up it expands and presents: (*a*) The olivary body and (*b*) the tubercle of Rolando. The **lateral column** is a band which passes upwards between the sulcus lateralis ventralis and the sulcus lateralis dorsalis. Above, it passes behind the lower part of the olivary body, and here a greyish prominence, the **grey tubercle of Rolando**, comes to the surface. Beyond this the lateral column can be followed as a narrow band behind the olive as far as the transverse groove at the lower border of the pons. The **olivary body** is an ovoidal prominence from twelve to sixteen millimetres long, which extends upwards as far as the transverse groove at the lower border of the pons. It is separated from the pyramidal body by the sulcus lateralis ventralis, and marked off externally by the sulcus postolivaris. Its lower end is crossed by the external arciform fibres. The **external arciform fibres** emerge from the anterior longitudinal fissure and from the sulcus lateralis ventralis, and arch round the pyramidal and olivary bodies to join the restiform body of the same side.

The **posterior area of the medulla** is occupied in its lower part by two slender fasciculi, each of which expands above into a tubercle. The inner of the two is called the funiculus gracilis, the outer the funiculus cuneatus. The **funiculus gracilis** is separated from its fellow of the opposite side by the posterior fissure. As it approaches the lower extremity of the fourth ventricle, it swells out into a prominence called the **clava.** The latter diverges from its fellow of the opposite side, bounding the fourth ventricle. When traced upwards it gradually tapers off into a fine point. To the inner margins of the diverging portions of the clavæ we find the obex and ligulæ attached, as already described (page 718). The **funiculus cuneatus** is placed between the funiculus last described and the lateral area of the medulla. At the level of the clava it swells out into a prominence, the **cuneate tubercle.** Above this point it disappears from the surface.

The upper part of the posterior area is occupied by the **restiform body.** The latter appears at first sight as if it were the continuation upwards of the funiculus cuneatus and of the lateral tract, and this was formerly described to be the case. It is now known, however, that it is formed by the direct cerebellar tract (page 742), the external arciform fibres, and the deep or internal arciform fibres. These constituents unite and form a rounded cord which proceeds upwards and then backwards to the cerebellum, forming the inferior peduncle of that body. In its lower part it is embraced by the roots of the auditory nerve. It then passes through a gap or interval between the superior and middle cerebellar peduncles, and ends in the superior vermiform process of the cerebellum in the nucleus fastigii. It is connected by the arcuate fibres with the columns of Goll and Burdach, partly by uncrossed and partly by crossed fibres. The uncrossed fibres have been shown to take a larger share in the formation of the restiform body than the crossed fibres (Darkschewitsch and Freud). The crossed fibres all reach the restiform body as **arciform fibres**; many of these fibres traverse the olivary nucleus but without entering into connection with its nerve-cells (Edinger); they also traverse the accessory olives and may pierce the ascending root of the trigeminal nerve; they all decussate at the raphe, and from thence proceed in two groups, superficial and deep arciform fibres. The **superficial arciform fibres** emerge through the anterior fissure of the medulla, some also through the sulcus paramedianus ventralis, and arch round the pyramidal body and olive to join the restiform body. In this part of their course they pass between the root-fibres of the ninth, tenth, eleventh, and twelfth nerves. The **deep arciform fibres,** after crossing in the raphe, traverse the olivary nucleus of the opposite side, and pass thence, through the substance of the medulla, into the restiform body.

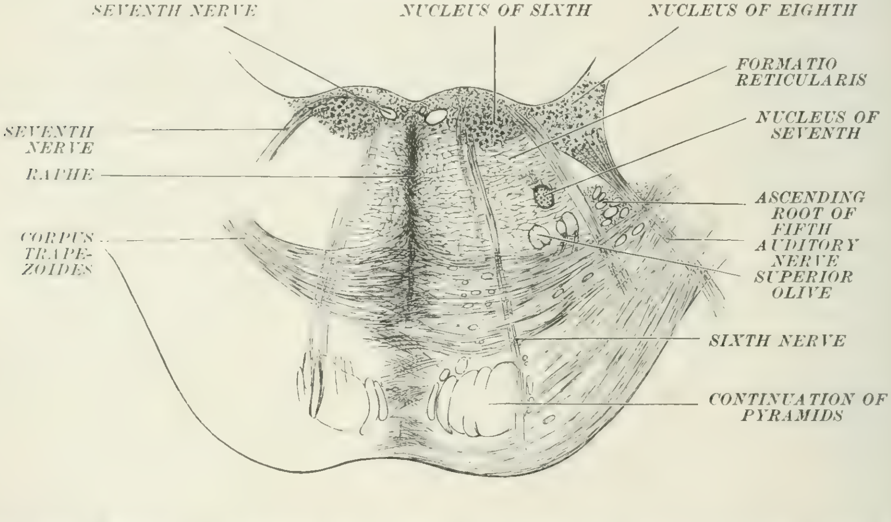
The olivary body also sends fibres to the restiform body. Fibres pass out of the hilum and cross in the raphe; they then traverse the olivary body of the opposite side and join the restiform body.

As already mentioned, the superficial origins of some of the cranial nerves appear on the surface of the medulla. The sixth, seventh, and eighth nerves come to the surface in the transverse groove between the medulla and pons (fig. 411). The twelfth nerve appears by a row of filaments in the groove between the olivary and pyramidal bodies, and in a line with these filaments, opposite the decussation of the pyramids, the upper part of the anterior root of the first cervical nerve comes to the surface. Between the olivary and restiform bodies, the ninth, tenth, and the upper part of the eleventh nerves make their appearance, and behind the latter the upper filaments of the posterior root of the first cervical nerve reach the surface.

Dissection.—If the student has followed out the dissection previously recommended, the brain will now be reduced to the medulla, the pons, the mesencephalon, and small portions of the hemispheres (chiefly thalamencephalon). He should now tear off the transverse fibres of the pons on one side of the middle line, so as to bring into view the flattened bundles which form the continuation of the pyramidal body through the pons. By tearing these pyramidal fibres in a sagittal direction, the dissector will be able to follow them through the crusta into the inner capsule. Lastly the dissector should make a series of transverse sections through the remaining portion of brain-substance. An inspection of figs. 423, 424, 429, 430, and 431 will materially aid him in comprehending the somewhat faint indications which he will observe in his sections.

The following are the principal points which can be made out by the unaided eye in an ordinary brain, hardened in spirit, and treated in the above-mentioned manner. (In a brain hardened in Müller's fluid many additional details can be made out.) In the uppermost sections the tegmental or red nucleus is readily recognised by its rounded outline; it lies below the optic thalamus, and extends backwards for a considerable distance (fig. 423). If the section pass through the external geniculate body, curved bands of white matter intersecting the grey matter can be seen. Sections through the upper part of the mesencephalon show the red nucleus in the tegmentum, the substantia nigra, the crusta, and the aqueduct of Sylvius. Lower down, the decussation of the superior peduncles of the cerebellum forms a conspicuous white centre in the tegmentum; the grey matter surrounding the aqueduct is distinct in colour from the rest of the section, and on the ventral side of this grey matter the posterior longitudinal bundle can be faintly made out. Sections through the inferior corpora quadrigemina show the posterior longitudinal bundle more distinctly; the superior peduncles of the cerebellum lie on the ventral side of the bundle, touching one another at the raphe, but commencing to rise up around the sides of the aqueduct; ventral to these the tract of the fillet may be seen as a white band; and ventrally to the fillet the longitudinal fibres of the pons are well seen intersecting the transverse fibres. Sections through the valve of Vieussens (fig. 429) show the superior peduncles of the cerebellum in the form of distinct white crescents placed laterally to the floor of the fourth ventricle. The posterior longitudinal bundle is now very distinct. It appears pear-shaped in cross-section with the narrow end pointing outwards and abutting against the substantia ferruginea; the latter stands out as a conspicuous dark spot. The tract of the fillet is easily recognised as a white flattened oval bundle. The area mapped out between the posterior longitudinal bundle, the superior peduncles of the cerebellum, and the tract of the fillet, is occupied by the formatio reticularis. In sections distal to this, the posterior longitudinal bundle and the tract of the fillet rapidly lose their distinctness, and in the medulla little can be made out as a rule except the olivary nucleus. The latter appears as a thin wavy grey line occupying the interior of the olivary body.

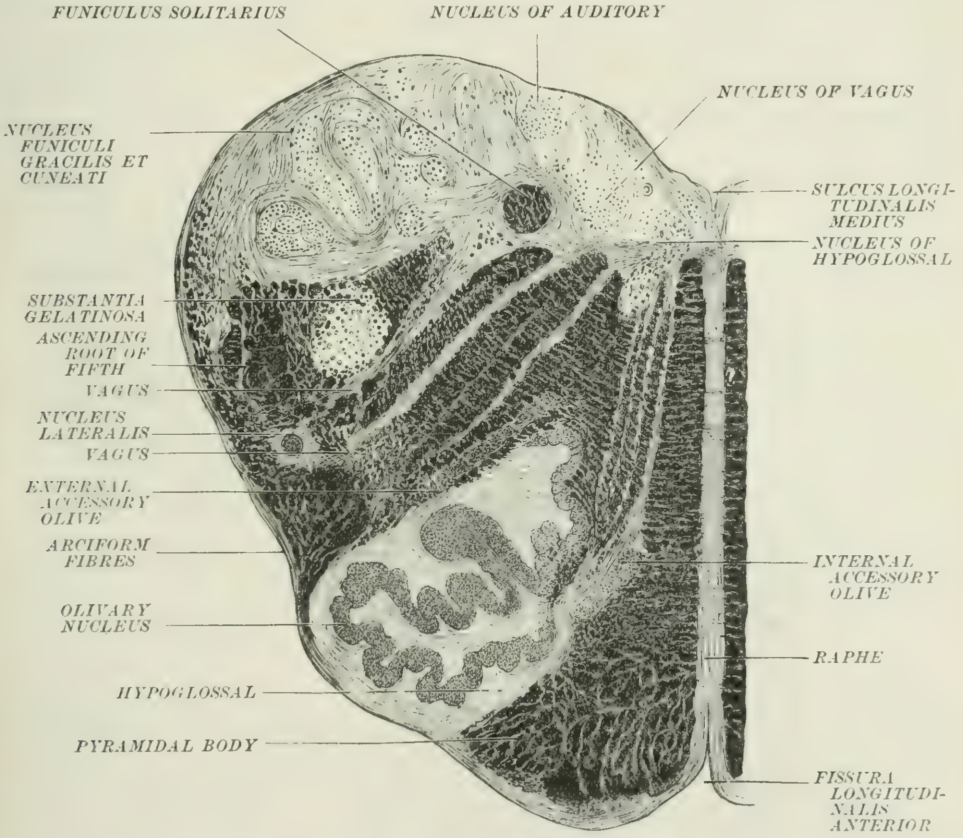
FIG. 430.—TRANSVERSE SECTION OF THE PONS NEAR THE CENTRE OF THE FOURTH VENTRICLE. (Schwalbe.)



Internal structure of the medulla.—Transverse sections of the medulla show that it is composed of symmetrical halves separated by a central raphe. The raphe is entirely formed by decussating fibres. Each lateral half is composed of both grey and white matter. The white matter will be dealt with in common with the tracts of the spinal cord and with the cranial nerves.

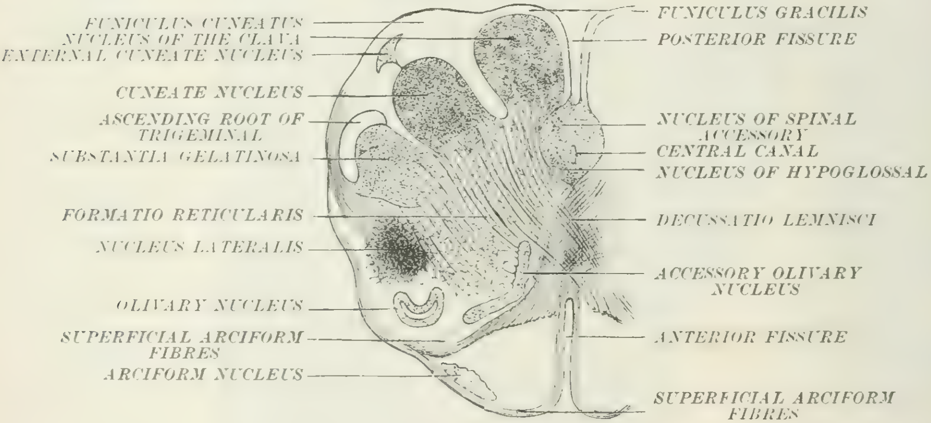
The **arrangement of the grey matter** in the medulla is, for the most part, not visible to the unaided eye, and therefore will be dealt with very briefly here. It is usually classified into two categories: (*a*) Representatives of the grey crescents of the spinal cord; and (*b*) nuclei or aggregations of grey matter not represented in the spinal cord. As will be seen on consulting the section on the Spinal Cord, the grey matter of the latter consists of a pair of bilaterally symmetrical grey crescents which are united in the middle line by a grey commissure. In the centre of this commissure is the central canal of the cord. The central canal extends upwards into the lower or distal part of the medulla, but, in the upper part of the last-named structure, the posterior columns diverge from one another so that the central canal opens out and expands into the floor of the fourth ventricle. Therefore the ependyma which surrounds the central canal, together with the grey masses at the bases of both anterior and posterior horns, is spread out on the floor of the fourth ventricle. From the nerve-cells in this grey matter some of the cranial nerves, which take their origin in the medulla, arise. The grey matter of the base of the anterior horn suffers but little displacement, and lies in a column on each side of the sulcus longitudinalis medianus, and from this a motor nerve (the twelfth) arises. The sixth nerve arises in series with the twelfth in the tegmental region of the pons, and the nuclei of the fourth and third nerves continue this motor column of cells brainwards in the floor of the aqueduct of Sylvius. The grey matter of the base of the posterior horn is displaced laterally, so that it underlies the surface markings which have been described above as ala cinerea and tuberculum acusticum, and from this grey matter the sensory parts of the tenth and ninth nerves and part of the eighth nerve arise. The heads of both of the horns of the grey crescents are also represented in the medulla. At

Fig. 431.—Transverse Section of the Medulla a little above the Lower Extremity of the Fourth Ventricle. (After Krause.)


FUNICULUS SOLITARIUS
NUCLEUS OF AUDITORY
NUCLEUS OF VAGUS
NUCLEUS FUNICULI GRACILIS ET CUNEATI
SULCUS LONGITUDINALIS MEDIUS
NUCLEUS OF HYPOGLOSSAL
SUBSTANTIA GELATINOSA
ASCENDING ROOT OF FIFTH
VAGUS
NUCLEUS LATERALIS
VAGUS
EXTERNAL ACCESSORY OLIVE
ARCIFORM FIBRES
INTERNAL ACCESSORY OLIVE
OLIVARY NUCLEUS
RAPHE
HYPOGLOSSAL
PYRAMIDAL BODY
FISSURA LONGITUDINALIS ANTERIOR

the decussation of the pyramids (fig. 438) large bundles of fibres pass from the lateral columns of the cord to cross over to the opposite side and appear in the anterior column of the medulla, forming the greater part of the pyramids. These bundles of fibres cut through the necks of the anterior horns so as to completely amputate the heads of the horns. A little higher up each head is thrust into a more lateral position by the increased size of the pyramids, and forms the nucleus lateralis and the nucleus ambiguus (fig. 432). The motor nuclei of the portion of the eleventh which arises in the medulla, and of the tenth and ninth nerves, are regarded as derivatives from the head of the anterior horn, and the series is continued upwards by the nucleus of the seventh (at the junction of the pons and medulla), and in the pons by the motor nucleus of the trigeminal. A little above the decussation of the pyramids, bundles of fibres, chiefly from the funiculi gracilis and cuneatus, pass forwards and cut through the neck of the posterior horn, and then decussate, forming the sensory or upper pyramidal decussation (decussatio lemnisci). The separated head of the posterior horn (substantia gelatinosa Rolandi) is continued upwards as far as the accessory sensory nucleus of the fifth nerve. This substantia gelatinosa is one of the sensory nuclei of the fifth nerve, and is covered externally by a band of white fibres, concave inwards, the ascending root of the trigeminal nerve (fig. 432). At one point the substantia gelatinosa approaches very near the surface, and forms the grey tubercle of Rolando.

FIG. 432.—TRANSVERSE SECTION OF THE MEDULLA IN THE REGION OF THE DECUSSATIO LEMNISCI. (Schwalbe.)


FUNICULUS CUNEATUS
NUCLEUS OF THE CLAVA
EXTERNAL CUNEATE NUCLEUS
CUNEATE NUCLEUS
ASCENDING ROOT OF TRIGEMINAL
SUBSTANTIA GELATINOSA
FORMATIO RETICULARIS
NUCLEUS LATERALIS
OLIVARY NUCLEUS
SUPERFICIAL ARCIFORM FIBRES
ARCIFORM NUCLEUS
FUNICULUS GRACILIS
POSTERIOR FISSURE
NUCLEUS OF SPINAL ACCESSORY
CENTRAL CANAL
NUCLEUS OF HYPOGLOSSAL
DECUSSATIO LEMNISCI
ACCESSORY OLIVARY NUCLEUS
ANTERIOR FISSURE
SUPERFICIAL ARCIFORM FIBRES

Of the nuclei which are apparently without representatives in the grey matter of the spinal cord, the most important is the **olivary nucleus**; this is a crumpled bag of grey matter enclosing white matter and occupying the interior of the olivary body. It can easily be seen with the unaided eye in cross-sections of the medulla. It presents a marked resemblance, in miniature, to the corpus dentatum of the cerebellum, and is often called the corpus dentatum of the olivary body. It presents an opening or hilum which opens downwards and inwards. The **nucleus of the clava** and the **nucleus cuneatus** are not directly represented in the cord, but their connection with the posterior horns can be seen in sections through the lower part of the medulla; they have probably the same anatomical value as a column of nerve-cells (Clarke's column) in the dorsal region of the spinal cord (Testut). Other nuclei of smaller size are found in the medulla; the nucleus arciformis and the accessory olives will serve as examples of these (fig. 432). None of these smaller nuclei are visible to the unaided eye.

Specific Gravity and Weight of the Brain

The average specific gravity of the brain is about 1036. The white matter is somewhat more heavy (sp. gr. 1040) than the grey matter (sp. gr. 1034).

The adult male brain weighs on an average 49·5 ounces; the female brain is somewhat lighter, and weighs from 5 to 5·5 ounces less than the male.

The cerebrum forms about 87·5 per cent. of the entire brain; the cerebellum about 10·5 per cent.; and the pons and medulla about 2 per cent.

Weight of the Spinal Cord

In the adult, the spinal cord, when all extraneous structures have been removed, weighs from 1 to 1·5 ounces.

For description of Cranio-cerebral Topography see Section X.

THE RELATIONS OF THE BRAIN TO THE WALLS OF THE CRANIAL CAVITY

In this section the subject of cranio-cerebral topography will be dealt with from a purely anatomical standpoint, for the precise methods by which the exact positions of the more important fissures, sulci, convolutions, and areas can be ascertained and mapped out on the surface of the head in the living subject are fully described in Section X, whilst here only a very general survey of the relations of the brain to the cranial bones will be given.

The parts of the brain which lie in close relation with the walls of the cranial cavity are the olfactory bulb and tract, the inferior and outer surfaces of the cerebral hemispheres, the lower surfaces of the lateral lobes of the cerebellum, the anterior surfaces of the medulla and pons, and the pituitary body.

Certain of these portions of the brain lie in relation with the basi-cranial axis,—that is, with the basi-occipital, the basi-sphenoid, and the ethmoid bones,—whilst others are separated by the membranes only from the sides and vault of the cranial space. Considering the former portions first, the anterior surface of the medulla oblongata, which is formed by the anterior pyramids, lies, posteriorly, upon the upper surface of the basi-occipital bone. More anteriorly the anterior surface of the pons rests upon the basi-sphenoid, from which it is partly separated by the basilar artery and the sixth pair of cranial nerves. In front of the dorsum sellæ the pituitary body is lodged in the pituitary fossa; still further forwards the olfactory tracts lie in grooves on the upper surface of the presphenoid section of the sphenoid bone; and in front of the sphenoid the olfactory bulbs rest upon the cribriform plates of the ethmoid.

Behind and laterally to the posterior part of the foramen magnum the lateral lobes of the cerebellum are in relation with the cranial wall, resting upon the lower parts of the supra- and the posterior parts of the ex-occipital portions of the occipital bone, whilst, anteriorly, each is in relation with the inner surface of the mastoid process and the posterior surface of the petrous portion of the temporal bone. The area of the skull wall which is in close relationship with the cerebellar hemispheres may be indicated, on the external surface of the skull, by a line which commences from the lower part of the external occipital protuberance; thence it runs upwards and outwards. It crosses the superior curved line a little beyond its centre, and, continuing in the same direction, it crosses the lower part of the lambdoid suture and reaches a point directly above the asterion (the meeting-point of the occipital, temporal, and parietal bones), whence it descends, just in front of the occipito-mastoid suture, to the tip of the mastoid process; there it turns inwards to its termination at the margin of the foramen magnum, immediately behind the posterior end of the occipital condyle.

The other portions of the brain which lie in close relation with the cranial walls are the lower and external surfaces of the cerebral hemispheres.

The lower surface of each cerebral hemisphere consists of two parts, an anterior and a posterior, which are separated by the stem of the Sylvian fissure. The anterior part, formed by the orbital surface of the frontal lobe, rests upon the upper surfaces of the orbital plate of the frontal bone and the small wing of the sphenoid; it is therefore in close relation with the upper wall of the orbital cavity. The posterior part, behind the Sylvian fissure, is formed by the anterior portion of the temporal lobe, including its apex. The apex itself projects against the orbital plate of the great wing of the sphenoid bone, and it is in relationship with the posterior part of the outer wall of the orbit. The lower surface of the hemisphere, behind the apex of the temporal lobe, is in contact with the upper surfaces of the great wing of the sphenoid and the petrous part of the temporal bone.

The external surfaces of the cerebral hemispheres have the most extensive relationships with the cranial wall, and it is more especially to these surfaces that the practical surgeon turns his attention. The general area in which the outer surface of each cerebral hemisphere is in relation with the skull bones is readily indicated by a series of lines which correspond with the positions of its supraciliary, the infero-lateral, and the supero-mesial borders.

The line marking the supraciliary margin of the hemisphere commences at the nasion (the mid-point of the fronto-nasal suture); it passes outwards above the supraciliary ridge, crosses the temporal ridge, then, turning backwards in the temporal fossa, it reaches the parieto-sphenoidal suture, along which it continues backwards to its posterior extremity.

The line marking out the infero-lateral border commences at the posterior end of the parieto-sphenoidal suture, whence it passes downwards, in front of the spheno-squamous suture, to the pterygoid ridge (infra-temporal crest); there it turns backwards; running parallel with and internal to the zygomatic arch, it crosses the root of the zygoma, and ascending slightly it passes above the external auditory meatus; continuing backwards with an inclination upwards it reaches a point immediately above the asterion; thence it descends, and, crossing the lower part of the lambdoid suture and the superior curved line, it passes inwards to the lower part of the external occipital protuberance.

The supero-mesial border is defined by a line which runs from the nasion to the inion; this line should be drawn about 5 mm. to the outer side of the sagittal suture, because the mesial area is occupied by the superior longitudinal sinus, and it should be further away from the middle line on the right than on the left side because the sinus tends to lie more to the right side.

The area of the skull wall enclosed by the three lines which mark the positions of the supraciliary, infero-lateral, and the supero-mesial borders of the cerebral hemisphere is formed by the vertical plate of the frontal bone, the parietal bone, the great wing of the sphenoid, the squamous part of the temporal, and the upper section of the supra-occipital segment of the occipital bone; it covers the outer surfaces of the frontal, parietal, temporal, and occipital lobes and the fissures and sulci which bound and mark them.

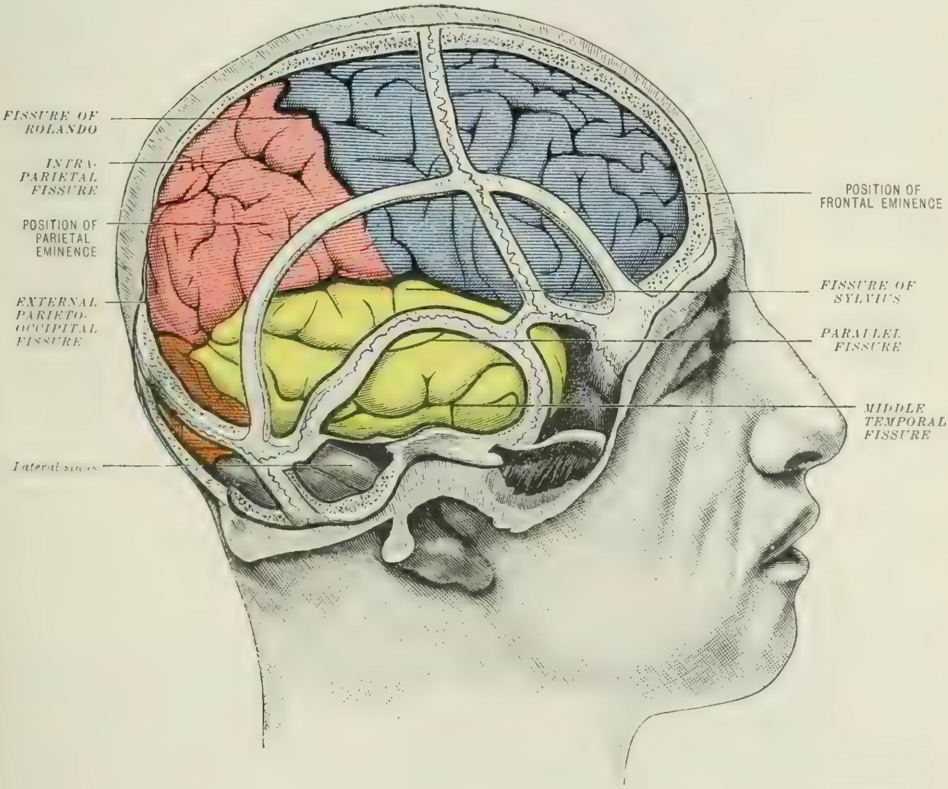
The frontal bone covers the superior, middle, and inferior frontal convolutions, except their posterior extremities, which are beneath the parietal bone (fig. 433). The ascending limb of the fissure of Sylvius, which cuts into the posterior part of the inferior frontal convolution, runs parallel with and under cover of the lower part of the coronal suture or immediately in front of it, and the anterior horizontal limb is parallel with and beneath the upper margin of the great wing of the sphenoid. The parietal bone is in relation with the outer surfaces of four lobes of the brain. Speaking very generally, it may be said that the anterior third covers the posterior part of the frontal lobe, including the ascending frontal convolution and the posterior ends of the superior, middle, and inferior frontal convolutions and the upper and lower precentral sulci, whilst the posterior two-thirds are superficial to the parietal lobe, the posterior part of the temporal lobe, the anterior part of the occipital lobe, the posterior part of the horizontal limb of the Sylvian fissure, the upper and lower post-central sulci, the intraparietal sulcus, the posterior sections of the first and second temporal sulci, and the external parieto-occipital fissure. The fissure of Rolando is beneath the parietal bone at the junction of its middle and anterior thirds (fig. 433).

The upper end of the fissure of Rolando lies 55 per cent. of the whole length of the naso-inionic line behind the nasion; it is 55 mm. from the coronal suture in dolichocephalic, and 54·4 mm. in brachycephalic heads. The lower end of the fissure is immediately above the posterior horizontal limb of the fissure of Sylvius; it lies beneath the point of intersection of the auriculo-bregmatic line with a line drawn from the stephanion (the point where the temporal ridge cuts the coronal suture) to the asterion (Macalister). In skulls of a sagittal length of 18 cm. and over this point is 45·5 per cent. of the horizontal arc from the glabella to the inion, and in skulls of less than 18 cm. it is 46 per cent. of the same arc posterior to the glabella.

The position of the posterior horizontal limb of the fissure of Sylvius varies; its posterior part is always under cover of the parietal bone and it terminates either in front of or below the parietal eminence, but the anterior part may be above, beneath, or below the squamo-parietal suture. In the adult the anterior part of the fissure runs upwards and backwards from the posterior end of the spheno-parietal suture along the anterior part of the squamo-parietal suture to its highest point; thence it continues in the same direction beneath the parietal bone towards the lambda, terminating either in front of or below the parietal eminence. In the child, however, the fissure is considerably above the line of the squamo-parietal suture (fig. 434), which it gradually approaches, attaining its adult position about the ninth year; this change of position, which occurs during the first nine years, is due partly to the ascent of the sutural line and partly to the descent of the fissure on the surface of the brain.

FIG. 433.—DRAWING OF A CAST OF THE HEAD OF AN ADULT MALE.

(Prepared by Professor Cunningham to illustrate cranio-cerebral topography.)

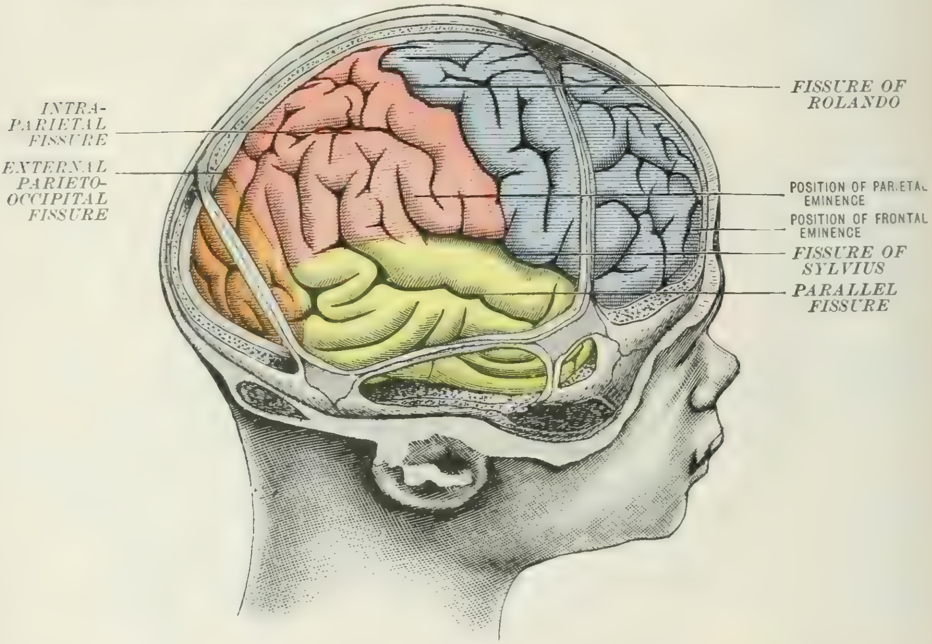

FISSURE OF ROLANDO
INTRA-PARIETAL FISSURE
POSITION OF PARIETAL EMINENCE
EXTERNAL PARIETO-OCCIPITAL FISSURE
Lateral sinus
POSITION OF FRONTAL EMINENCE
FISSURE OF SYLVIUS
PARALLEL FISSURE
MIDDLE TEMPORAL FISSURE

The upper end of the external parieto-occipital fissure usually lies about 5 mm. in front of the lambda, and the course of the fissure may be indicated by a line drawn from 5 mm. in front of the lambda to a point immediately above the asterion, and, as the latter point corresponds with the pre-occipital notch on the infero-lateral border of the hemisphere, the line in question will indicate the adjacent margins of the parietal, temporal, and occipital lobes of the brain.

The occipital bone is in close relation with the cerebellum, as already pointed out, but it also covers the posterior part of the outer surface of the occipital lobe of the cerebrum. The great wing of the sphenoid covers the outer surface of the apex of the temporal lobe, and the squamous part of the temporal bone covers the anterior parts of the superior, middle, and inferior temporal convolutions and the sulci which separate them.

In every consideration of the topographical relations of the cerebral convolutions to the walls of the cranial cavity it must be borne in mind that the conditions are not constant, and that, therefore, the relations are variable. The three main factors upon which this variability depends are age, sex, and the shape of the skull. As examples of the variations which occur it may be mentioned that the fissure of Sylvius is higher in the child than in the adult (compare figs. 433 and 434). The upper end of the fissure of Rolando is further away from the coronal suture in the female and the child than in the adult male, and in dolichocephalic than in brachycephalic heads. The angle formed between the line of the fissure of Rolando and the mid-sagittal plane, which averages about 69° in the adult, is more acute in dolichocephalic heads, and the external parieto-occipital fissure is further forwards in the child, and possibly in the female, than it is in the adult male.

Fig. 434.—Drawing of a Cast of the Head of a Newly-born Male Infant.
(Prepared by Professor Cunningham to illustrate cranio cerebral topography.)

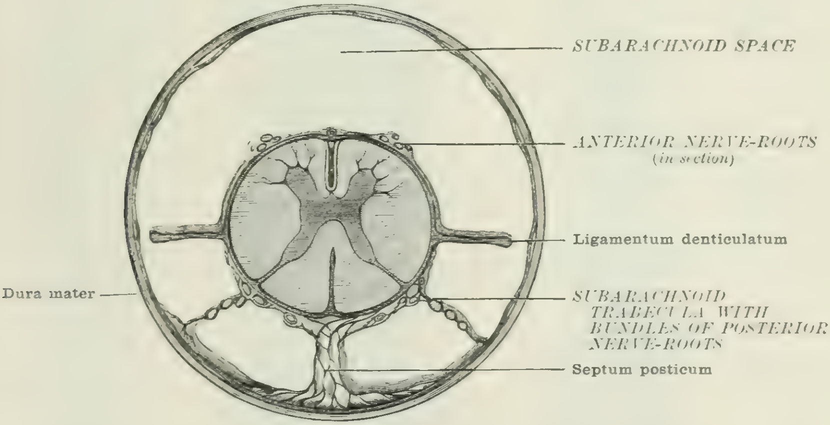

INTRA-PARIETAL FISSURE
EXTERNAL PARIETO-OCCIPITAL FISSURE
FISSURE OF ROLANDO
POSITION OF PARIETAL EMINENCE
POSITION OF FRONTAL EMINENCE
FISSURE OF SYLVIUS
PARALLEL FISSURE

THE SPINAL CORD

The **spinal cord** is the elongated portion of the cerebro-spinal axis which is contained within the spinal canal. It extends from the level of the transverse ligament of the atlas to the body of the second lumbar vertebra. Occasionally it only extends as far as the body of the first lumbar vertebra. It is invested, in common with the brain, by three membranes: dura mater, arachnoid, and pia mater. The portions of these membranes which are contained within the cranial cavity, and are therefore in relation to the brain, have been already described (page 671). There are, however, certain differences between the cranial and the spinal meninges; therefore, a short separate description of the latter will be necessary.

Dissection.—The subject being placed on its face, the neural canal may be laid open in the usual manner by cutting through the pedicles of the vertebræ and removing the neural arches of the sacrum. The cord and its membranes should be first examined *in situ*. About three inches of the theca should be ripped up at the junction of the dorsal and lumbar regions for this purpose. The entire cord with the membranes should then be removed by dividing both cord and membranes at the level of the articulation between the atlas and axis and cutting through the nerves as they enter the intervertebral foramina. Two or three of the lower lumbar or upper sacral nerves should be cut sufficiently long to preserve the ganglia on the posterior roots. The cord should now be pinned out with its posterior surface uppermost in a cork-lined tray and dissected under water. On laying open the dura mater by a mesial longitudinal incision, the arachnoid will come into view and will be rendered more evident by blowing air between it and the pia mater with a blowpipe. On slitting up the arachnoid some of the coarser strands of the subarachnoid tissue may be made out. The posterior and anterior nerve-roots will also be seen with the ligamentum denticulatum between them. The connection of the latter with the pia mater is well seen under water. The pia mater appears white and glistening, and when traced downwards is very obviously continuous with the filum terminale. The last-named structure stands out conspicuously among the duller-coloured nerve-roots which constitute the cauda equina. On the anterior aspect of the cord the linea splendens will be seen. Lastly the student should make a series of transverse sections through the cord and compare the disposition of the grey and white matter in the different regions (fig. 439).

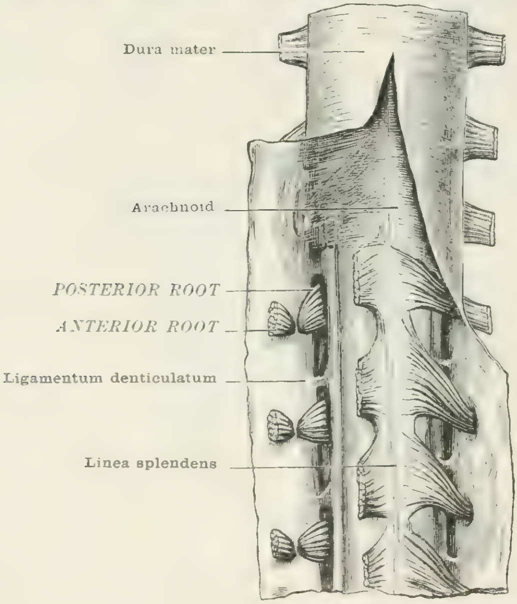
FIG. 435.—TRANSVERSE SECTION OF THE SPINAL CORD AND ITS MEMBRANES. (After Key and Retzius.)


SUBARACHNOID SPACE
ANTERIOR NERVE-ROOTS (in section)
Ligamentum denticulatum
Dura mater
SUBARACHNOID TRABECULA WITH BUNDLES OF POSTERIOR NERVE-ROOTS
Septum posticum

The **DURA MATER** forms a loose sheath or theca around the cord. It invests not only the cord but also the elongated nerve-roots, which (under the name of cauda equina) extend beyond the cord. It invests the cauda equina as far as the second or third sacral vertebra, but at this level it converges so as to form a blunt hollow cone, and is represented lower down only by the sheath of the filum terminale. By means of this sheath it is attached to the base of the coccyx. Its outer surface is rough and is loosely connected by fatty tissue to the ligaments and periosteum which line the neural canal. Some stronger retinacula connect it to the posterior common ligament. Its inner surface, smooth and shining, is separated from the arachnoid by a narrow subdural space. It is connected to the cord by a special development of the pia mater—the ligamentum denticulatum. It is continuous through the foramen magnum with the supporting layer of the dura mater of the brain. It sends tubular prolongations around the spinal nerves. These prolongations gradually merge into the connective tissue sheaths (epineurium) of the nerves. Each tube is divided by a septum into two compartments, one for the anterior, and one for the posterior root of the spinal nerve.

The differences between the dura mater of the brain and cord may be summarised as follows:—The dura mater of the cord does not send processes or infoldings into the fissures of the cord. It represents only the supporting layer of the dura mater of the brain. The periosteal layer is represented by the periosteum of the neural canal, but is separated from the supporting layer by fatty tissue, and by some venous plexuses. Hence this periosteum is only brought into relation with the dura mater proper by the fact, already noticed (page 672), that the dura mater of the cranium is directly continuous by the medium of the posterior occipito-axial ligament with the periosteum of the neural canal.

FIG. 436.—VIEW OF THE MEMBRANES OF THE SPINAL CORD. (Ellis.)

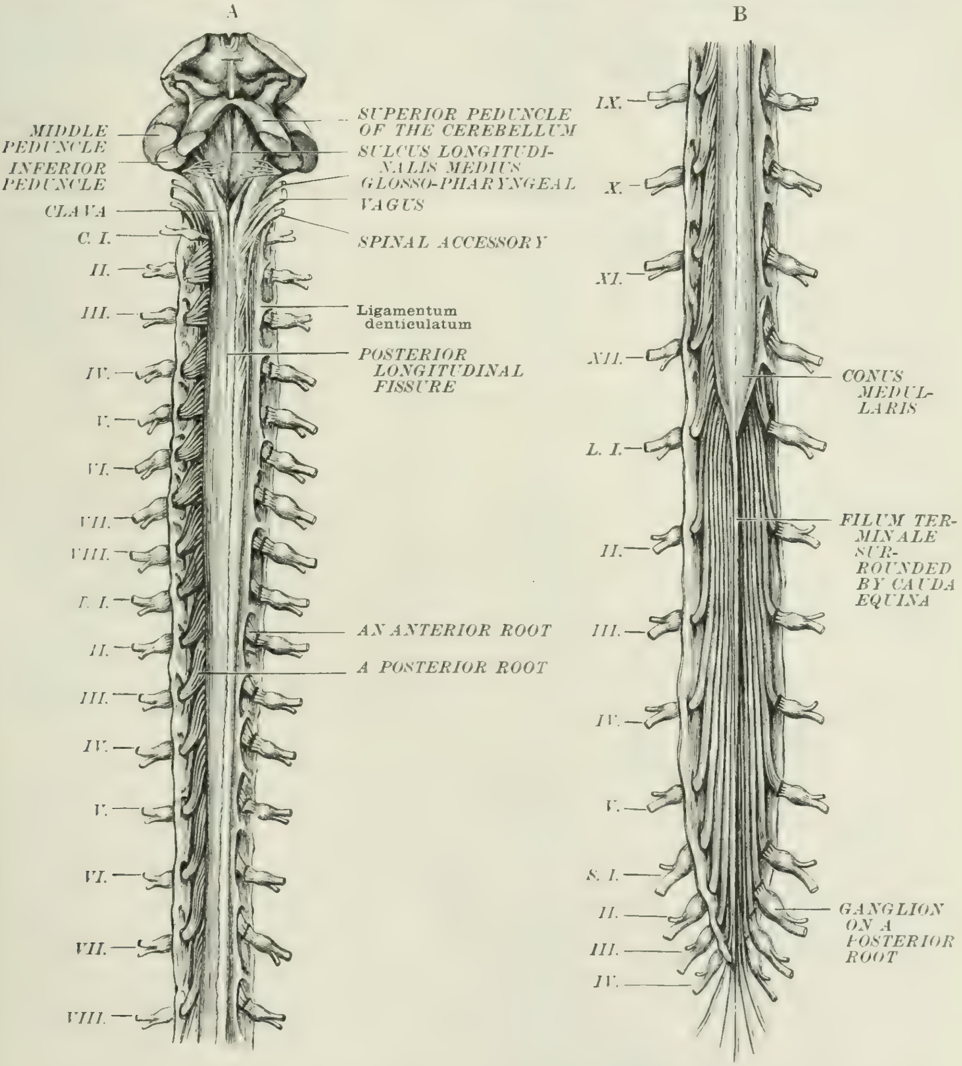


The **ARACHNOID** is separated from the dura mater by a narrow subdural space, and is connected to the dura mater only opposite the attachments of the ligamentum denticulatum, to be presently described. It is a thin membrane resembling the cerebral arachnoid, with which it is continuous. It sends tubular investments along the nerve-roots. These investments eventually become continuous with the perineural sheaths of the nerves. It extends downwards within the theca as far as the second or third sacral vertebra, forming a common investment to the bundle of nerve-roots constituting the cauda equina.

The **subarachnoid tissue** is much less abundant in the spinal portion than in the cerebral part of the subarachnoid space. It passes from arachnoid to pia mater in the form of delicate threads, which are separated from one another by comparatively wide intervals. It also gives support to the nerve-roots as they cross the subarachnoid space (fig. 435). An incomplete membranous septum, the **septum posticum** (Key and Retzius), passes from arachnoid to pia mater opposite the posterior septum of the spinal cord, and serves to conduct blood-vessels to the cord. The space is also partially divided into a posterior and an anterior compartment by the ligamentum denticulatum.

The **PIA MATER** of the cord consists of two layers, an outer and an inner, the latter of which represents, and is continuous with, the pia mater of the brain. Both layers dip into the anterior fissure of the cord, and the inner layer is continuous with the posterior septum. The outer layer is strong and fibrous, and presents certain localised thickenings which require separate description; these are the ligamentum denticulatum and the linea splendens. The filum terminale may be conveniently described along with these.

FIG. 437.—POSTERIOR VIEW OF THE MEDULLA OBLONGATA AND OF THE SPINAL CORD, WITH ITS COVERINGS AND THE ROOTS OF THE NERVES. (Hirschfeld and Leveillé.)


A
B
SUPERIOR PEDUNCLE OF THE CEREBELLUM
MIDDLE PEDUNCLE
SULCUS LONGITUDINALIS MEDIUS
INFERIOR PEDUNCLE
GLOSSO-PHARYNGEAL
CLAVA
VAGUS
C. I.
SPINAL ACCESSORY
II.
III.
Ligamentum denticulatum
POSTERIOR LONGITUDINAL FISSURE
IV.
V.
VI.
VII.
VIII.
D. I.
II.
AN ANTERIOR ROOT
A POSTERIOR ROOT
III.
IV.
V.
VI.
VII.
VIII.
IX.
X.
XI.
XII.
CONUS MEDULLARIS
L. I.
II.
FILUM TERMINALE SURROUNDED BY CAUDA EQUINA
III.
IV.
V.
S. I.
II.
III.
IV.
GANGLION ON A POSTERIOR ROOT

The **ligamentum denticulatum** is a fibrous band which is attached on each side of the cord about midway between the anterior and posterior nerve-roots. It is continuous by its inner margin with the pia mater. Its outer margin is characteristically scalloped or denticulated, and presents about twenty-one pointed processes by which it is attached to the dura mater. These processes do not pierce the arachnoid, but receive funnel-shaped sheaths from it (Key and Retzius). The highest of these processes is at the level of the foramen magnum, and is placed between the hypoglossal nerve and the vertebral artery. In the upper region of the cord one denticulation is regularly placed between the point of exit of each nerve and the next nerve below; lower down the arrangement becomes less regular. It is continuous below with the filum terminale. The **linea splendens** (Haller) is a conspicuous linear thickening which is placed in the middle line in front of the cord. It presents a silvery white appearance. It is continuous below with the filum terminale. The **filum terminale** is the continuation of the pia-matral sheath of the cord, and contains but little nervous matter in its interior. It is easily distinguished by its shining white appearance from the nerve-roots among which it lies. It is a slender strand which extends from the pointed lower extremity of the spinal cord to the lower end of the sacrum, or first piece of the coccyx, opposite which it is attached to the bone. As already mentioned, it receives a sheath from the dura mater in the lower part of its course.

EXTERNAL CHARACTERS OF THE SPINAL CORD

The spinal cord is about eighteen inches in length, and forms (by weight) about two per cent. of the cerebro-spinal axis. It is cylindrical in form, and is slightly compressed from before backwards, so that the transverse exceeds the antero-posterior diameter. It is continuous with the medulla oblongata above at the decussation of the pyramids; below it tapers off into a cone, the **conus medullaris,** the apex of which is continued downwards by the filum terminale. It follows the curvatures of the canal in which it is placed, and therefore describes two curves, the upper or cervical convex forwards, and the lower or dorsal concave forwards.

In two regions of the cord distinct enlargements are visible: these are called the cervical and the lumbar enlargements. The large size of the nerves which are given off to supply the limbs, forming the brachial and lumbo-sacral plexuses, obviously account for these enlargements of the cord. The increase in size is almost entirely produced by an increase in the transverse diameter. The **cervical enlargement** is more pronounced than the lumbar swelling. It commences at the level of the third cervical vertebra, and ends at the second dorsal. It is at its maximum at the level of the sixth cervical vertebra. The **lumbar enlargement** commences at the level of the ninth dorsal vertebra, and reaches its maximum at the twelfth dorsal; below this point it rapidly diminishes and passes into the conus medullaris.

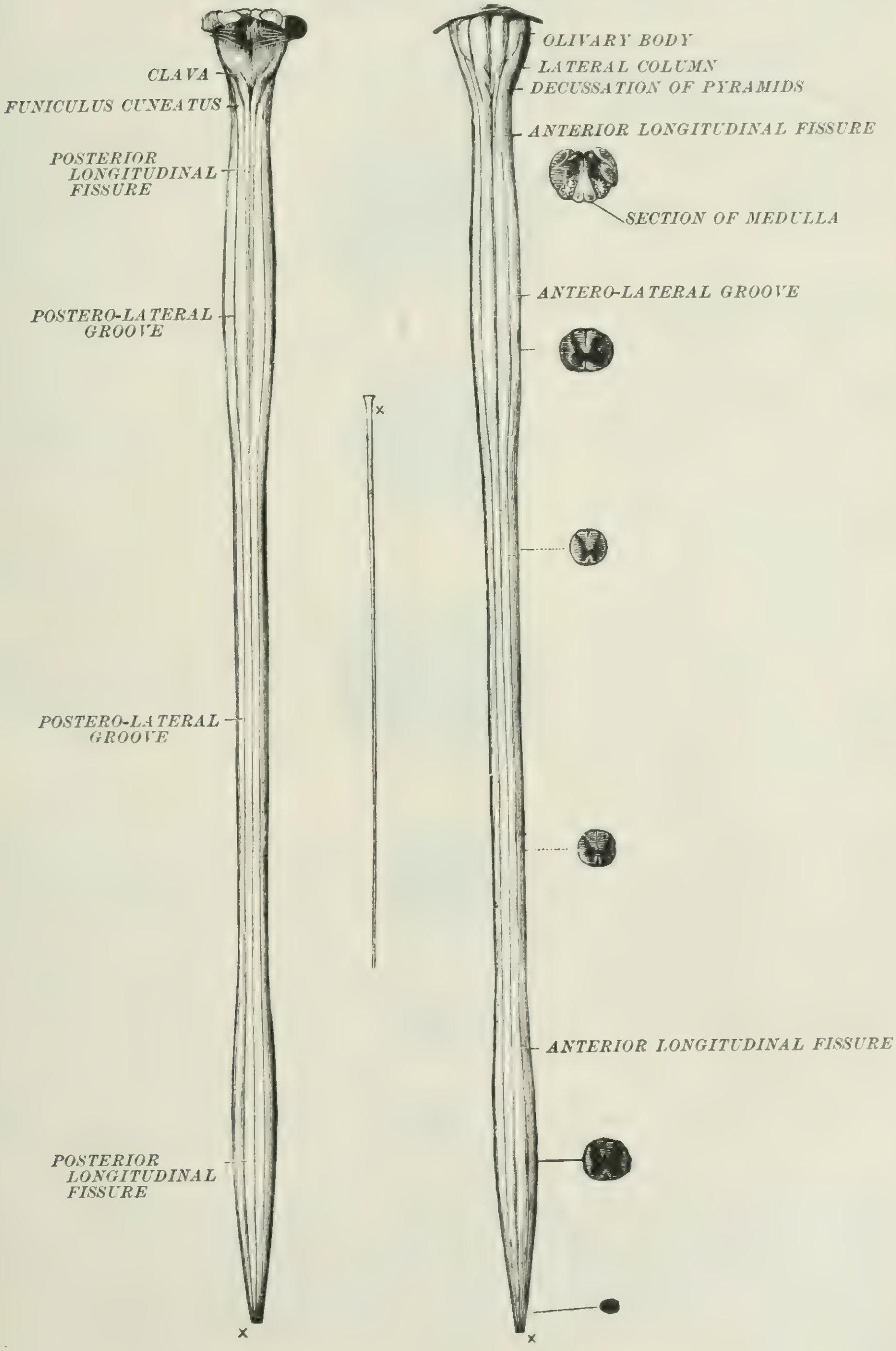
The spinal cord is bilaterally symmetrical, the two halves being defined by an anterior fissure and a posterior septum. From the antero-lateral and postero-lateral aspects of the cord the anterior and posterior nerve-roots emerge, forming two parallel series of fasciculi which extend throughout the entire length of the cord. In the upper cervical region the intrathecal course of the nerve-roots is very short, and the direction taken by the roots is nearly transverse. As the roots are traced downwards in the dorsal and lumbar regions, they become progressively longer, and descend with an increasing degree of obliquity. Hence the lumbar and sacral nerve-roots have a very long intrathecal course. They extend beyond the termination of the cord (which, it will be remembered, ends at the body of the second lumbar vertebra), and lie within the theca in a sheaf somewhat resembling a horse's tail, and therefore called the **cauda equina.**

The cord is divided into definite macroscopical areas by one fissure, two sulci, three septa, and the exits of the anterior nerve-roots.

The fissure.—The anterior fissure separates the cord into two lateral areas anteriorly (fig. 439). It is relatively wide and extends from the surface to the anterior white commissure, attaining a depth equal to about one-third the antero-posterior diameter of the cord. It contains a fold of pia mater and branches of the anterior spinal vessels. It is continued above along the anterior surface of the medulla, being partially interrupted by the decussation of the pyramids, and it terminates at the foramen cæcum just below the pons (fig. 441).

Fig. 438.—Anterior and Posterior View of the Spinal Cord.
(Modified from Quain.)

X represents the filum terminale.

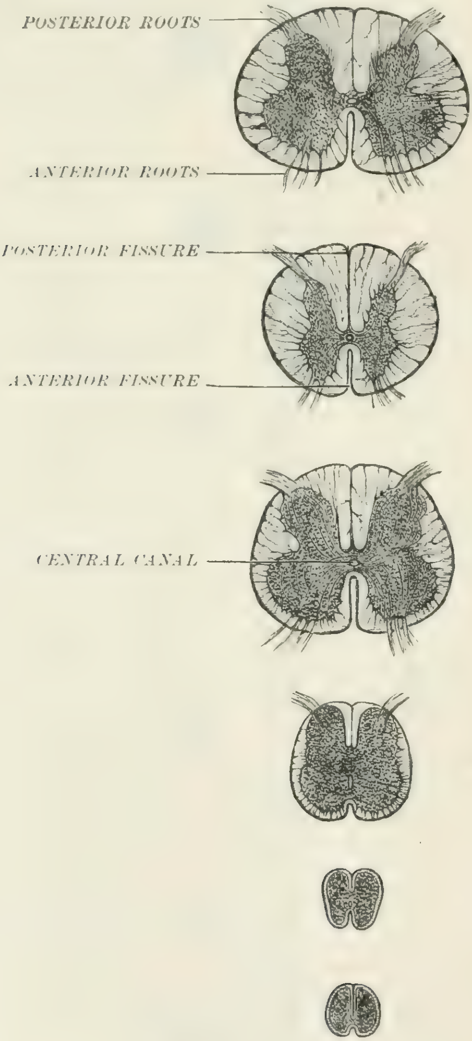

CLAVA
FUNICULUS CUNEATUS
POSTERIOR LONGITUDINAL FISSURE
POSTERO-LATERAL GROOVE
POSTERO-LATERAL GROOVE
POSTERIOR LONGITUDINAL FISSURE
x
x
OLIVARY BODY
LATERAL COLUMN
DECUSSATION OF PYRAMIDS
ANTERIOR LONGITUDINAL FISSURE
SECTION OF MEDULLA
ANTERO-LATERAL GROOVE
ANTERIOR LONGITUDINAL FISSURE
x

The two sulci are placed dorso-laterally (fig. 438) and the posterior nerve-roots emerge from them. They serve to divide each half of the cord into a posterior and an antero-lateral area or column (fig. 439).

The anterior nerve-roots emerge from the antero-lateral aspects of the cord, not from grooves or sulci, but in a relatively scattered manner. They divide the antero-lateral columns into anterior and lateral portions (fig. 439).

The three septa lie in the dorsal part of the cord; they are a median and two lateral. The postero-median septum extends throughout the whole length of the cord, separating it into lateral halves dorsally (fig. 439). It consists of neuroglial tissue containing branches of the posterior spinal vessels, and it passes from the pia mater to the posterior, or grey, commissure. The postero-lateral septa are only seen in the dorsal and cervical regions. They extend from the pia mater into the posterior column, dividing it into postero-median and postero-lateral parts.

Fig. 439.—Sections through Different Regions of the Spinal Cord. (After Schwalbe.)



A. At the level of the sixth cervical nerve-roots.

B. At the mid-dorsal region.

C. At the centre of the lumbar enlargement.

D. At the upper part of the conus medullaris.

E. At the level of the fifth sacral nerve-roots.

F. At the level of the coccygeal nerve-roots.

INTERNAL STRUCTURE OF THE SPINAL CORD

In transverse section, each lateral half of the cord is seen to be composed of both grey and white matter, the latter being disposed on the surface. The grey matter is in the form of a crescent, which has been not inaptly compared (by Testut) to a large comma (❛). The head of the comma looks forwards and constitutes the anterior horn of grey matter; the tail forms the posterior horn, and the convexity looks inwards and is united to the grey crescent of the opposite side by the grey commissure. The two crescents, with the commissure, form a figure resembling a capital **H**. Within the grey commissure is the central canal of the cord, and in front of the grey commissure, occupying the floor of the anterior longitudinal fissure, is the anterior white commissure. Medullated fibres cross the middle line both in the white and in the grey commissure. The term commissure is somewhat misleading, as the majority of the nerve-fibres which pass from side to side are not commissural but decussating fibres.

The grey matter of the cord consists of two varieties: (*a*) Substantia gelatinosa, and (*b*) substantia spongiosa. The former (*a*) covers the head of the posterior horn like a cap (**substantia gelatinosa Rolandi**), and is also found around the central canal (**substantia gelatinosa centralis**). The latter is continued into the ependyma of the cerebral ventricles. (*b*) The substantia spongiosa is much more extensive than the substantia gelatinosa, and contains large nerve-cells. These cells are arranged in definite groups, forming columns in the grey matter.

The cell columns in the anterior cornua are arranged as follows:

Mesial (fig. 440 A).	Dorso-mesial. Ventro-mesial.		These columns are the most constant in all situations, and are believed to supply the spinal muscles.
Lateral (fig. 440 A).	Dorso-lateral.		Best marked opposite the limb nerves to which they give origin.
	Ventro-lateral.	Lateral.	In cervical region, gives origin to spinal accessory.
		Mesial.	In cervical region, gives origin to phrenic nerve.

The cells of the posterior cornu.—The cells of the posterior cornu are less regular than those of the anterior cornu in arrangement, but several groups are described. They are (1) peripheral cells, some of which possess long, curved processes, and hence are called comet cells; (2) central cells; (3) basal cells; (4) the cells of the substantia gelatinosa; and (5) solitary cells, which are scattered irregularly and which vary in size. The protoplasmic or dendritic processes of the cells of the posterior cornu permeate the gray matter of the cornu; their axis-cylinder processes or axons run in various directions, and their terminations are for the most part unknown; some of them, however, pass to the anterior cornu and to the anterior commissure, and these are believed to issue from the cord as the small fibres of the anterior nerve-roots.

Clarke's column of cells (fig. 440 A).—This column of cells lies at the base of the posterior cornu internally. It consists of large ovoid cells whose long axes are parallel with the axis of the cord. The column is limited to the dorsal region, but cells of similar nature, occupying a similar position, are found in the lumbar region of the cord opposite the second and third sacral nerves, where they form Stilling's nucleus. Others are recognisable in the cervical region, and they are probably represented in the medulla by the cells of the nucleus gracilis and the nucleus cuneatus. Many of the axons of the cells of this column pass upwards to the cerebellum in the dorso-lateral ascending cerebellar tract, and some are probably distributed, as anabolic or inhibitory nerves, to the blood-vessels, glands, and to the walls of the alimentary canal.

The intermedio-lateral tract.—The intermedio-lateral tract or column of nerve-cells lies at the base of the anterior cornu externally; it is limited to the dorsal region, but cells occupying relatively similar positions are found in the cervical and lumbar regions also. The axons of its cells probably constitute the katabolic or motor nerve-fibres of the muscles of the glandular and vascular systems.

A middle column of cells can be recognised in the centre of the grey matter at the junction of the anterior and posterior cornua. It is more or less distinct throughout the whole length of the cord, and its function is unknown.

The term **processus reticularis** is applied to a number of strands of grey matter which project into the white matter and anastomose together on the outer side of the base of the posterior cornu.

The **central canal of the cord** is lined by columnar epithelium; it is continued into the filum terminale for about half the length of the latter, and is here somewhat dilated; a few nerve-fibres accompany the canal into the filum terminale, and are supposed to be rudimentary coccygeal nerves. The canal is dilated in the conus medullaris, forming an irregular cavity, the **sinus rhomboidalis inferior,** or **ventriculus terminalis.**

In transverse sections through the spinal cord made in the dissecting room the general arrangement of the grey and white matter can be made out, and sections from the different regions of the cord can be distinguished from one another in fresh specimens, especially with the aid of a pocket lens.

In the upper cervical region (at the level of the second or third cervical nerves) the grey matter forms an H-shaped outline bearing a great resemblance to the outline in the dorsal region (fig. 439, B). Sections through this region are very difficult to distinguish from sections of the dorsal cord with the naked eye. The microscope, however, reveals the absence of Clarke's column and the presence, in some cases, of root-fibres of the spinal accessory nerve.

In the lower cervical region (fig. 439, A) the cord is elliptical in outline and the anterior horns of the grey crescents are very large; the section shows a certain similarity to a section through the lumbar region (fig. 439, C). In the latter, however, the anterior horns are more evenly rounded, the general outline approaches more nearly to a circle, and the proportion of grey to white matter has greatly increased.

Sections of the dorsal region can be easily recognised with the microscope by the presence of Clarke's column, which is confined to the dorsal, lowest part of the cervical, and the uppermost part of the lumbar regions.

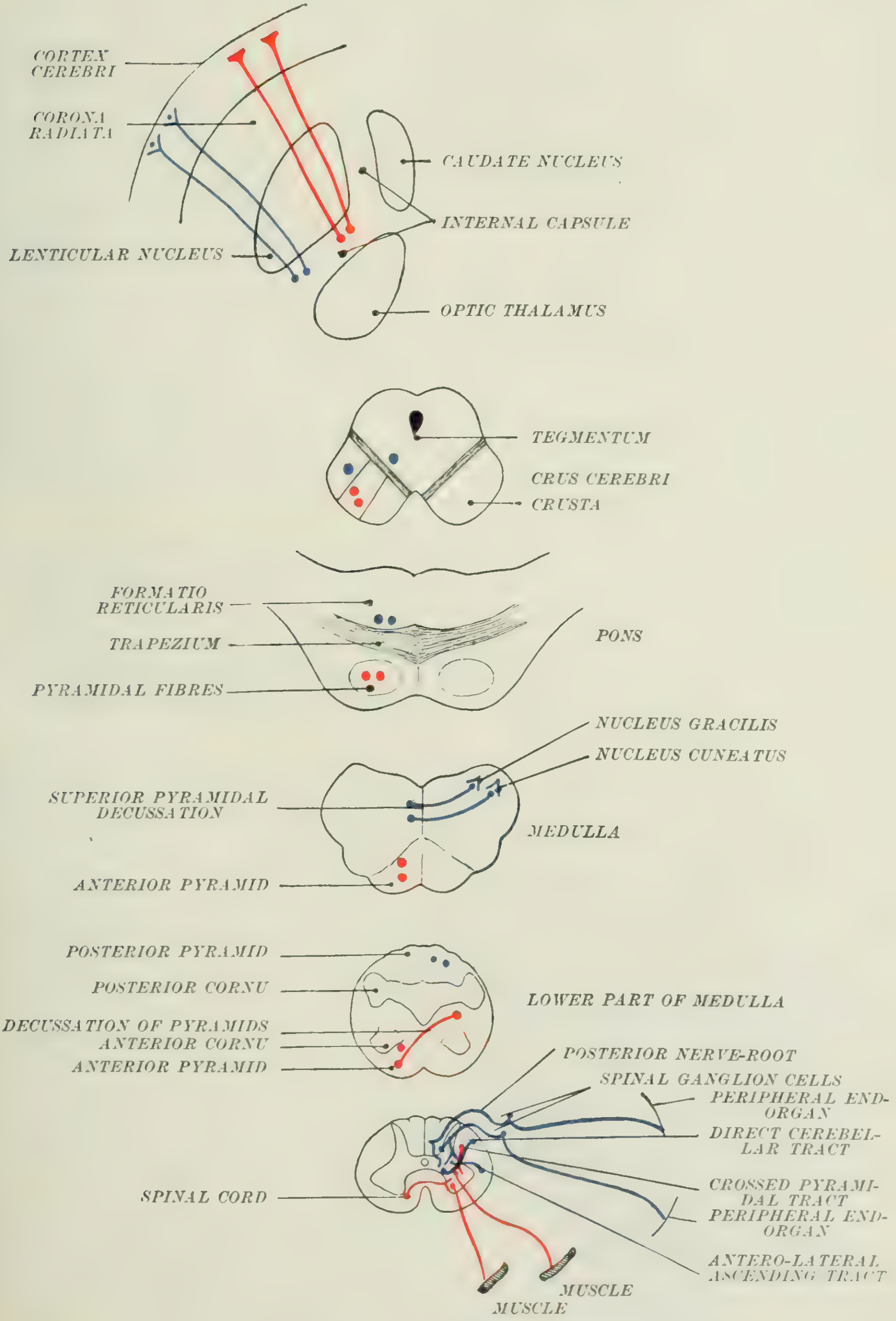
Sections through the part of the cord from which the sacral nerves arise show a great preponderance of grey matter. This feature becomes more marked as the termination of the cord is approached (fig. 439, D, E, and F).

THE DEEP CONNECTIONS AND ASSOCIATIONS OF THE SPINAL NERVES

But little information can be gained from a mere macroscopical or microscopical examination of the adult cord concerning the course of the fibres of the nerve-roots within it, and the facts detailed here have been chiefly ascertained by embryological and pathological research. The success of the **embryological method** depends upon the fact that certain tracts or groups of fibres myelinate (or acquire their medullary sheath) at an earlier period than others, and therefore these tracts of medullated fibres can be followed and recognised through a series of sections. The **pathological method** rests upon the influence which nerve-cells exert upon nerve-fibres: this so-called trophic influence depends upon the fact that every nerve-fibre is a process of a nerve-cell and can only exist and retain its functions as long as it remains connected with the cell. The trophic cell, therefore, of every nerve-fibre is that cell from which the fibre arises and with which it is in direct structural continuity. If the trophic cell is destroyed the nerve-fibre dies, or if the structural continuity of the cell and fibre is interrupted by section, then the fibre degenerates and dies beyond the point of interruption, and the degeneration and death occur simultaneously throughout the whole length of the separated portion. In connection also with the trophic influence of nerve-cells it must be borne in mind that every nerve-cell with its processes constitutes a distinct entity, called a **neuron,** which has close associative relations with other nerve-cells and with various tissues of the body by means of its processes, but it is absolutely devoid of structural

FIG. 440.—DIAGRAM SHOWING PATHS TRAVERSED BY SENSORY AND MOTOR NERVE-FIBRES AND THEIR COURSE TO AND FROM THE CORTEX OF THE BRAIN.

(Sensory fibres blue ; motor fibres red.)


CORTEX CEREBRI
CORONA RADIATA
CAUDATE NUCLEUS
INTERNAL CAPSULE
LENTICULAR NUCLEUS
OPTIC THALAMUS
TEGMENTUM
CRUS CEREBRI
CRUSTA
FORMATIO RETICULARIS
TRAPEZIUM
PONS
PYRAMIDAL FIBRES
NUCLEUS GRACILIS
NUCLEUS CUNEATUS
SUPERIOR PYRAMIDAL DECUSSATION
MEDULLA
ANTERIOR PYRAMID
POSTERIOR PYRAMID
POSTERIOR CORNU
LOWER PART OF MEDULLA
DECUSSATION OF PYRAMIDS
ANTERIOR CORNU
ANTERIOR PYRAMID
POSTERIOR NERVE-ROOT
SPINAL GANGLION CELLS
PERIPHERAL END-ORGAN
DIRECT CEREBELLAR TRACT
SPINAL CORD
CROSSED PYRAMIDAL TRACT
PERIPHERAL END-ORGAN
ANTERO-LATERAL ASCENDING TRACT
MUSCLE
MUSCLE

continuity with them. The centre of the neuron is the body of the cell. The processes of the neuron form two sets, the protoplasmic, dendritic or afferent, and the axis-cylinder process, which is termed the axon or efferent process. The dendritic processes of the neurons of the brain and spinal cord are usually short, relatively numerous, and profusely branched, but the dendritic or afferent process of a spinal ganglion cell frequently runs a long distance before dividing into its terminal ramifications. The terminal filaments of the dendrites may be associated either with the arborisations of the axons and dendrites of other cells or with specialised end organs. The axons may be short or long; those of the cord and brain terminate either in ramifications round other nerve-cells or in association with special end organs. The axons of the spinal ganglia enter the cord and divide into an ascending and a descending branch, both of which give off numerous collaterals, and they terminate in ramifications around other nerve-cells.

The knowledge of the above facts, and the careful study of the degenerations resulting from the section of nerve-roots and the destruction of nerve-cells, combined with repeated observations on the phenomena observable during the development of the nerve-roots and the spinal cord, have led to the formation of the following conclusions concerning the deep connections of the spinal nerve-roots.

The anterior roots.—The majority of the fibres in the anterior nerve-roots are axons of the cells of the anterior cornua, but some of the smaller fibres are derived from the cells of the posterior cornua, and from the cells of Clarke's column and the intermedio-lateral tract, whilst others which pass to the roots from the white columns are believed to be processes of some of the nerve-cells of the cerebellum; therefore if the nerve-cells in the regions mentioned are destroyed, or if the anterior nerve-roots are divided beyond their exits from the cord, the nerve-fibres which form them degenerate to their peripheral terminations.

The posterior roots.—The fibres of the posterior nerve-roots are processes of the cells in the posterior root ganglia. The fibres in each root external to the ganglion are the afferent or dendritic processes, and the fibres in the internal portion of the root are the axons or efferent processes, which pass into the cord; therefore if the posterior nerve-root is divided external to the ganglion the peripheral portion undergoes degeneration, but if the division is made internal to the ganglion then the central part degenerates and the positions of its fibres in the substance of the cord become recognisable.

Two groups of fibres are distinguishable in each posterior root as it enters the cord, an outer or lateral group of small fibres, and an inner group of large fibres intermixed with some small fibres. The fibres of the outer group enter the cord over the apex of the posterior cornu and turning upwards they form a small column called the marginal bundle or Lissauer's column (fig. 440A), in which they run for a short distance before entering the substantia gelatinosa Rolandi. The inner group passes into the outer part of the posterior column, and it is possible that some of its fibres terminate in Clarke's column, but the majority, if not all, divide into two branches, one of which passes upwards and the other downwards; both the main fibre and its two terminal branches give off numerous collateral branches which enter the grey matter and ramify round the cells of Clarke's column and the cells of the posterior and anterior cornua of the same side, and some pass through the grey commissure to the grey matter of the opposite side. The terminations of the descending branches of the posterior root-fibres are not definitely known, but they are believed to be in the grey matter of the lower segments of the cord. The ascending branches pass upwards to the medulla, gradually nearing the postero-median septum as they ascend, and they terminate in arborisations round the cells of the nucleus gracilis and the nucleus cuneatus in the medulla oblongata.

Tracts of the spinal cord.—The fibres which form the white columns of the spinal cord are the axons of nerve-cells of the cord, brain, or ganglia, which are passing upwards or downwards in the cord to terminate at a higher or lower level; the former are called ascending fibres, the latter descending, and the degenerations which occur in them are termed ascending and descending degenerations respectively.

Both the ascending and descending fibres are grouped in tracts, but it must be clearly understood that these tracts or columns are only recognisable during their development or when affected with disease or degeneration.

The following tracts are recognised in the posterior columns:—

Ascending { The postero-lateral, or Burdach's column.
The postero-mesial, or Goll's column.
Descending { The comma-shaped tract.
(fig. 440 A).

The two ascending columns are not distinguishable from each other below the mid-dorsal region, but above that level they are partially separated by a septum of neuroglia called the postero-lateral septum. The fibres of Goll's column are small and those of Burdach's column are large, but both are derived from the posterior nerve-roots, and as they pass upwards they give off collaterals which enter the grey matter.

Some of the fibres of the posterior ascending columns terminate in arborisations round the cells of the grey matter of the cord, but others pass upwards to the medulla oblongata, where the fibres of Goll's column ramify round the cells of the nucleus gracilis, and the fibres of Burdach's column arborise round the cells of the nucleus cuneatus.

The **descending or comma-shaped tract** is small, often ill-defined, and it lies in the midst of the postero-lateral ascending tract. It consists of fibres from the posterior roots which are passing downwards to lower segments of the cord.

The tracts which have been defined in the antero-lateral column are the following:—

Descending { Crossed pyramidal.
Direct pyramidal.
Antero-lateral descending cerebellar.
Ascending { Dorso-lateral, or direct cerebellar.
Antero-lateral ascending cerebellar.
Lissauer's column, or the marginal bundle.
Antero-lateral ground bundle.
(fig. 440 A).

The descending tracts of the antero-lateral column.—The **crossed pyramidal tract** is a somewhat triangular bundle of nerve-fibres lying in the dorsal part of the antero-lateral column, in front of and somewhat external to the posterior cornu. It is separated from the surface, except in the lower part of its extent, by the direct cerebellar tract (fig. 440A). Its fibres are the axons of nerve-cells in the cortex of the opposite side of the brain; they pass downwards through the corona radiata, the internal capsule, the crura cerebri, the pyramidal bundles of the anterior pyramid of the medulla to the decussation of the pyramids; there they cross the middle line and continue their descent in the opposite antero-lateral column; finally they leave the antero-lateral column and pass into the substance of the anterior cornu, where they terminate in ramifications round the motor cells (fig. 440A).

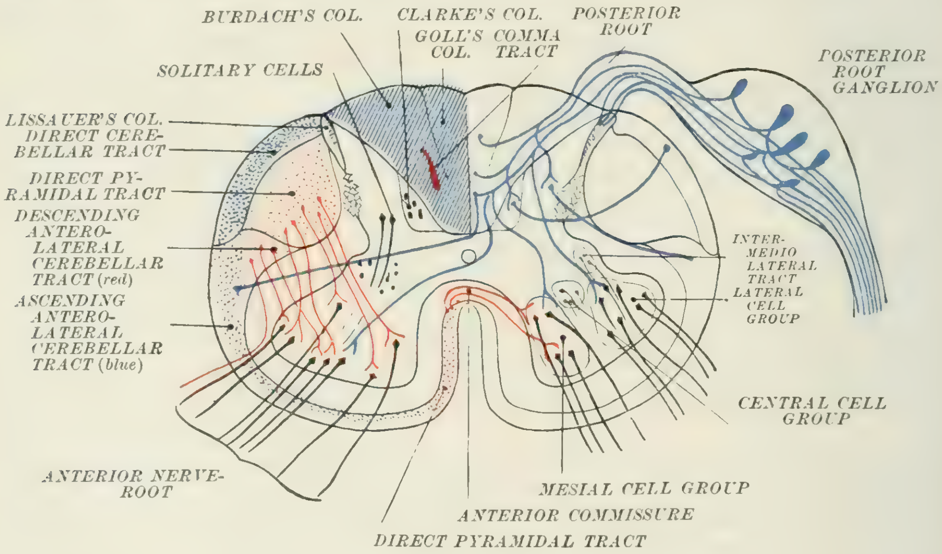
The **direct pyramidal tract** is a small quadrilateral bundle of nerve-fibres situated at the side of the anterior fissure. It cannot be traced downwards beyond the mid-dorsal region. Its fibres are the axons of the nerve-cells of the brain cortex of the same side, which have taken the course described in connection with the crossed pyramidal fibres as far as the medulla; then, instead of crossing to the opposite side, they have descended in the anterior column of the same side; ultimately, however, they reach the opposite side by passing through the anterior white commissure, and they terminate in ramifications round the motor cells of the anterior cornu.

The **descending antero-lateral column** is situated peripherally. It extends forwards from the crossed pyramidal and direct cerebellar tracts to the base of the direct pyramidal tract, but it is broader dorsally than ventrally, and its fibres are more or less mixed with those of the antero-lateral ascending cerebellar tract (fig. 440A). Its fibres are processes of nerve-cells situated in the vermiform process and the lateral lobe of the cerebellum; they descend to the cord through the middle peduncle of the cerebellum, and through the restiform body.

The ascending tracts of the antero-lateral column.—The **dorso-lateral** or **direct cerebellar tract** occupies the dorsal part of the periphery of the cord on the outer side of the crossed pyramidal tract, extending from the tip of the posterior cornu to the antero-lateral ascending and descending tracts (fig. 440A). It separates the crossed pyramidal tract from the surface, except in the lower dorsal region, where the pyramidal fibres intervene between it and Lissauer's column. Its fibres are processes of some of the cells of Clarke's column, and they terminate in ramifications in the cerebellum, to which they pass by the restiform body.

The **antero-lateral ascending cerebellar tract** occupies an area in front of the crossed pyramidal tract extending forwards to the region of the anterior nerve-roots. Its fibres are mingled with those of the descending antero-lateral tract, but they have a more limited anterior extension and they occupy a broader area posteriorly; they are processes of nerve-cells of the cord and possibly of the cells of the posterior cornu. They pass upwards through the reticular formation of the medulla and pons; some reach the cerebellum by the superior peduncle and others join the fillet.

FIG. 440A.—DIAGRAM OF THE TRACTS OF THE SPINAL CORD AND OF THE DEEP ORIGINS OF THE SPINAL NERVES.


BURDACH'S COL.
CLARKE'S COL.
POSTERIOR ROOT
GOLL'S COL.
COMMA TRACT
POSTERIOR ROOT GANGLION
SOLITARY CELLS
LISSAUER'S COL.
DIRECT CEREBELLAR TRACT
DIRECT PYRAMIDAL TRACT
DESCENDING ANTERO-LATERAL CEREBELLAR TRACT (red)
ASCENDING ANTERO-LATERAL CEREBELLAR TRACT (blue)
INTERMEDIO LATERAL TRACT
LATERAL CELL GROUP
CENTRAL CELL GROUP
ANTERIOR NERVE-ROOT
MESIAL CELL GROUP
ANTERIOR COMMISSURE
DIRECT PYRAMIDAL TRACT

Lissauer's column is a small bundle of small fibres situated at the apex of the posterior cornu dorsal to the crossed pyramidal and direct cerebellar tracts. It consists of the small fibres from the lateral parts of the posterior nerve-roots which are passing upwards to terminate in the grey matter of higher segments of the cord.

The **antero-lateral ground bundle** embraces the anterior cornu and the outer side of the base of the posterior cornu (fig. 440A); it represents all the antero-lateral column not included in the previously mentioned tracts, and it consists of ascending and descending commissural fibres passing between different segments of the cord.

THE PERIPHERAL NERVOUS SYSTEM

The cerebro-spinal nerves, together with the end-organs of these nerves, the sympathetic system and the ganglia which are connected to both the cerebro-spinal and the sympathetic nerves, make up the peripheral nervous system. The cerebro-spinal nerves are invariably paired, and, with a few exceptions (notably the vagus), are symmetrical in their origin, course, and distribution on the two sides of the body. The cranial nerves arise directly from the brain and pass out from the skull through foramina in the cranial wall. The spinal nerves arise by anterior and posterior roots from the spinal cord, and leave the spinal canal by passing through the intervertebral foramina. The first spinal nerve is somewhat exceptional, as its origin is partly from the medulla, and, moreover, it leaves the spinal canal by passing between the occipital bone and the atlas.

THE CRANIAL NERVES

The **cranial nerves** are classified into nine pairs by Willis, and into twelve pairs by Soemmerring. Willis's classification depends upon the manner in which the nerves pierce the dura mater; for example, the glosso-pharyngeal, vagus, and spinal accessory nerves all pierce that membrane opposite the jugular foramen, hence they collectively form a cranial nerve (the eighth) of Willis. In Soemmerring's classification each nerve-trunk is considered separately. Willis's classification was formerly in use; it is now, however, generally discarded in favor of Soemmerring's classification. The latter will be followed in this work.

The following table will explain the relation of Willis's to Soemmerring's classification:—

Willis		Soemmerring	Names
First pair of nerves		First pair of nerves	Olfactory
Second ,,		Second ,,	Optic
Third ,,		Third ,,	Oculo-motor
Fourth ,,		Fourth ,,	Pathetic or trochlear
Fifth ,,		Fifth ,,	Trigeminal or trifacial
Sixth ..		Sixth ..	Abducent
Seventh ..	Portio dura	Seventh ..	Facial
	Portio mollis	Eighth ..	Auditory
Eighth ,,		Ninth ..	Glosso-pharyngeal
		Tenth ,,	Pneumogastric or vagus
		Eleventh ..	Spinal accessory
Ninth ,,		Twelfth ,,	Hypoglossal

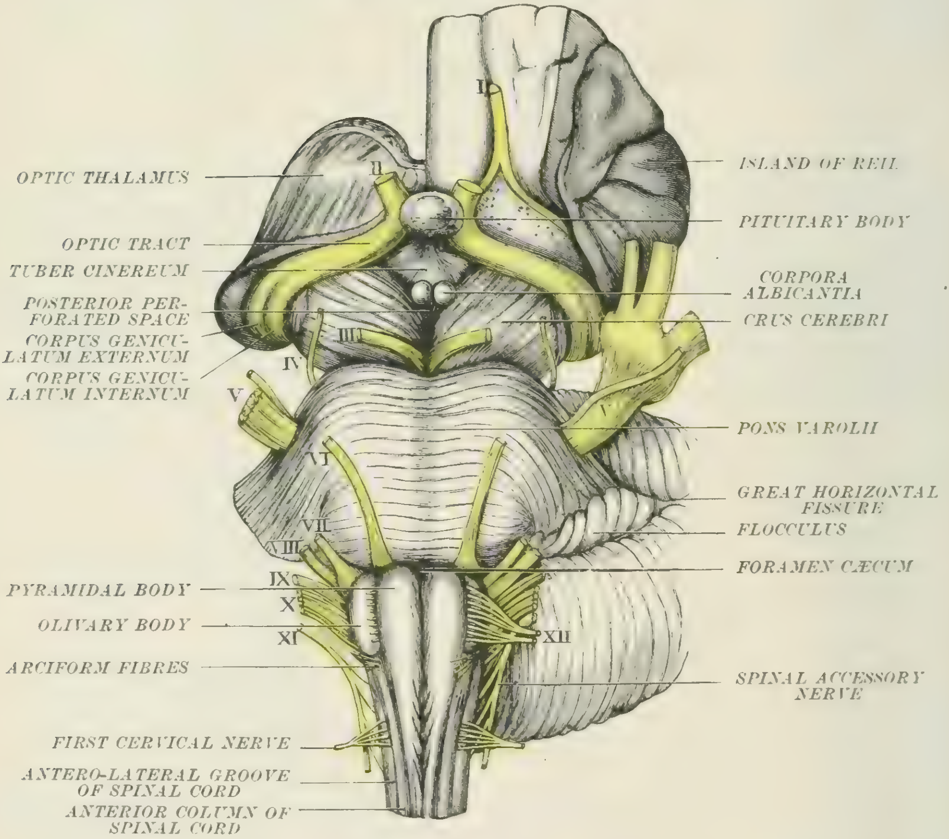
It will be well to notice here that the olfactory bulb and tract and optic nerves are not serially homologous with the other cranial nerves, but are rather outgrowths of the cerebral substance itself. The 'filaments of the olfactory nerve,' which pierce the cribriform plate of the ethmoid bone, correspond collectively to a cranial nerve. In the case of the optic nerve, the retina, as a study of its development shows, is a portion of the brain extruded beyond the cranial wall, and the ganglionic layer of the retina in all probability corresponds to the 'nucleus of origin' of an ordinary cranial nerve. The nervous elements which intervene between the ganglionic layer of the retina and the rods and cones therefore represent the true optic nerves.

Superficial and deep origins.—The point at which a cranial nerve emerges from the substance of the brain is called its superficial origin; while the collection of nerve-cells to which its fibres can be followed is called its deep origin. It must be clearly understood, however, that the deep origin is only the proximate origin of the nerve, the real origin is in the cerebral cortex. For example, injuries to the lower portions of the ascending parietal and ascending frontal convolutions almost as surely paralyse the facial and hypoglossal nerves as if the nuclei of these nerves had been destroyed in the medulla.

General distribution.—The olfactory, optic, and auditory nerves are exclusively nerves of special sense, and are distributed to the nose, the eye, and the ear, respectively. Of the remaining nerves, some are motor, others are mixed. The **motor nerves** are: the third, fourth, and sixth to the ocular muscles, the seventh to the platysma and to the superficial muscles of the face and scalp, and the twelfth to the muscles of the tongue. The **mixed** are the fifth, which is chiefly sensory to the face, teeth, eye, external ear, and fore part of the scalp, but also motor to the muscles of mastication; the ninth, which contains fibres for the special sense of taste, also ordinary sensory and motor fibres; the tenth, which conveys sensory fibres to the external ear, and both motor and sensory fibres to the pharynx, larynx, heart, lungs, trachea, œsophagus, and stomach; and the eleventh, which divides into a spinal part, wholly motor, destined for the sterno-mastoid and trapezius muscles, and a mixed or accessory part which joins the tenth.

Fig. 441.—Surface Origin of the Cranial Nerves.

(After Allen Thomson.—Quain.)


I
II
OPTIC THALAMUS
OPTIC TRACT
TUBER CINEREUM
POSTERIOR PERFORATED SPACE
CORPUS GENICULATUM EXTERNUM
CORPUS GENICULATUM INTERNUM
III
IV
V
VI
VII
VIII
IX
X
XI
XII
PYRAMIDAL BODY
OLIVARY BODY
ARCIFORM FIBRES
FIRST CERVICAL NERVE
ANTERO-LATERAL GROOVE OF SPINAL CORD
ANTERIOR COLUMN OF SPINAL CORD
ISLAND OF REIL
PITUITARY BODY
CORPORA ALBICANTIA
CRUS CEREBRI
PONS VAROLII
GREAT HORIZONTAL FISSURE
FLOCCULUS
FORAMEN CÆCUM
SPINAL ACCESSORY NERVE

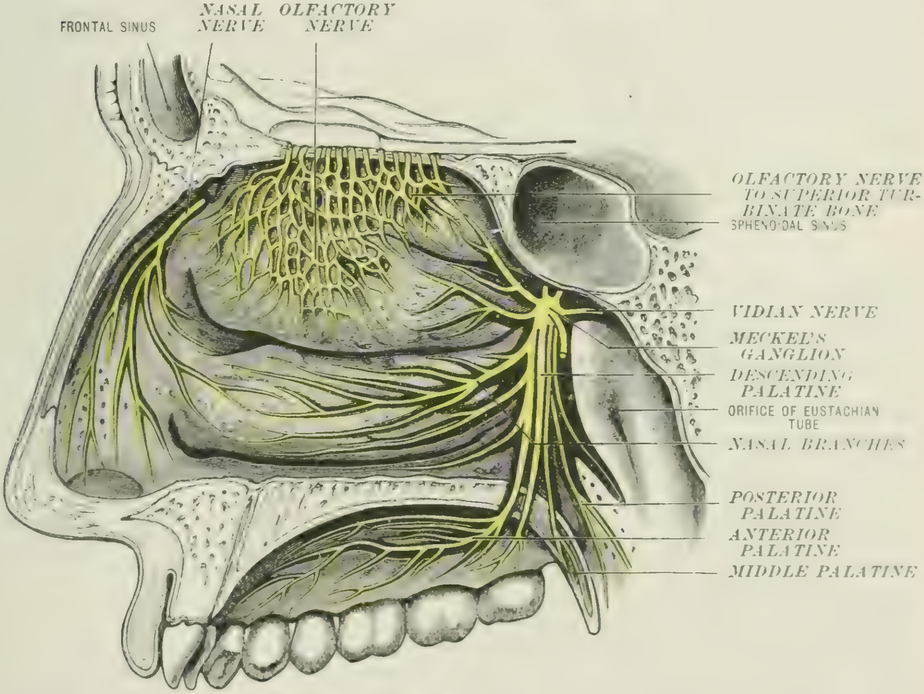
In the following pages the course of each nerve is described in order from its so-called deep origin to its peripheral distribution; the ultimate connection with the cortex is described in the anatomy of the brain. An exception is made, however, in the case of the olfactory and optic nerves, the cerebral connections of which are described with the nerves.

FIRST OR OLFACTORY NERVES

The olfactory nerves are twenty to thirty in number on each side. They rise from the lower surfaces of the olfactory bulbs, and are grey filaments devoid of white sheaths. They pass in two rows, inner and outer, through the foramina in the cribriform plate of the ethmoid. Entering the olfactory mucous membrane they anastomose together and afterwards break up into filaments. The filaments of the outer group are distributed over the upper and middle turbinal bones in the upper fifth of the outer wall of the nasal cavity, and those of the inner group over a similar extent of the upper part of the septum.

The olfactory nerve-fibres are processes of special olfactory cells in the upper parts of the nasal mucous membrane. They terminate in the olfactory bulb in ramifications which are interwoven with the dendrites of the mitral cells of the bulb forming with them the olfactory glomeruli. From the mitral cells fibres pass backwards into the olfactory tract. These may be classified into two groups, namely:—(*a*) Fibres which enter the cortex of the tract; and (*b*) fibres which pass through the white matter to other parts of the brain without becoming connected to the cortex of the tract. (*a*) From the cortex of the tract some fibres pass *viâ* the external white root to the cortex of the temporal lobe. Others enter the anterior commissure, and proceed to the cerebral cortex of the opposite side. (*b*) Of the fibres which pass directly through the tract, some pass by the external white root to the temporal lobe; others pass as a slender tract into the under border of the internal capsule, and so reach the front of the optic thalamus (Obersteiner). A commissural bundle of fibres, which passes from one olfactory tract to its fellow of the opposite side, *viâ* the anterior commissure, is also described.

FIG. 442.—NERVES OF THE NASAL CAVITY.


FRONTAL SINUS
NASAL NERVE
OLFACTORY NERVE
OLFACTORY NERVE TO SUPERIOR TURBINATE BONE
SPHENOIDAL SINUS
VIDIAN NERVE
MECKEL'S GANGLION
DESCENDING PALATINE
ORIFICE OF EUSTACHIAN TUBE
NASAL BRANCHES
POSTERIOR PALATINE
ANTERIOR PALATINE
MIDDLE PALATINE

As they pass through the foramina in the cribriform plate, the olfactory nerve-fibres are invested by sheaths derived from the dura mater.

SECOND OR OPTIC NERVES

The **optic nerves** appear at the base of the brain as a pair of round white cords, which arise from the optic chiasma. From the posterior aspect of the latter structure, two somewhat similar cords, the optic tracts, pass backwards and outwards. Each optic nerve is continuous, through the chiasma, with both optic tracts. It will be convenient to trace first the central connections of the optic nerves through the optic tracts, and afterwards to follow the nerves forwards from the optic chiasma to the eyeball.

The **optic chiasma** or **commissure** rests upon the optic groove, on the superior surface of the sphenoid bone. It is in relation above with the third ventricle, being separated only by a thin layer of grey matter from that cavity. The internal carotid arteries are close to its outer sides, behind it is the tuber cinereum, and in front the lamina cinerea, the anterior cerebral and the anterior communicating arteries.

Constitution of the optic chiasma.—Three sets of fibres are described in the optic chiasma, namely: (*a*) Fibres from one optic tract to the optic nerve of the same side; (*b*) fibres from one optic tract to the optic nerve of the opposite side; (*c*) commissural fibres passing from one optic tract to its fellow of the opposite side. (*a*) The **uncrossed fibres** proceed from the lateral or temporal half of the retina of the same side. They occupy the outer part of the chiasma. (*b*) The **crossed fibres,** which form the largest constituent of the chiasma, are derived from the mesial or nasal half of the retina, and pass into the optic tract of the opposite side. (*c*) The **commissural fibres** occupy the back part of the chiasma. They have nothing to do with vision. Two sets are described under the names of Gudden's and Meynert's commissures.

The **optic tract** passes backwards and outwards between the outer side of the tuber cinereum and the anterior perforated space, then it passes under cover of the temporal lobe, winding around the crus cerebri. As it applies itself to the latter, it adheres to it, and becomes flattened from above downwards. It next inclines upwards, and divides into an external and an internal root. These roots proceed towards the external and internal geniculate bodies, respectively. The **internal root** contains the fibres of Gudden's commissure.

A portion of the **external root** becomes connected with the nerve-cells in the external geniculate body; another part enters the pulvinar of the optic thalamus, while a third part passes in the superior brachium to the superior quadrigeminal body of the same side.

The fibres of the optic nerve terminate therefore amidst or in the ganglion cells of the external geniculate body, the pulvinar of the optic thalamus, and the superior quadrigeminal body; hence, these three bodies have been said to contain the nuclei of origin of the optic nerve. Other fibres, however, collectively termed the **optic radiation,** emerge from these three bodies, and pass through the most posterior part of the inner capsule to the occipital lobe, and thus the cortical origin of the optic nerve is established. The exact area of the cortex devoted to the sense of sight is still a matter of dispute, but the weight of evidence seems to be in favour of the cuneus being the cerebral centre of vision.

Other roots of the optic nerve are described, of which the direct cortical root (Wernicke and Gudden) is perhaps the most important. This root leaves the optic tract as the latter is crossing the crus cerebri, and runs upwards in the inner capsule to join the optic radiation. Another root is described which passes from the optic chiasma into the central grey matter of the third ventricle. The descending root (Stilling) enters the crus and is variously distributed; a portion of its fibres become connected with the oculo-motor nucleus, and thus a path for reflex movements of the iris and ciliary muscle is probably established.

Gudden's commissure.—Fibres emerge from the posterior quadrigeminal body, constituting its brachium, and enter the internal geniculate body. After partial interruption in the nerve-cells of the latter, these fibres are continued into the optic tract and pass across to the opposite side, forming the back part of the optic chiasma, to enter into a similar relation to the internal geniculate and posterior quadrigeminal bodies of the opposite side.

Meynert's commissure.—From the grey matter of the tuber cinereum fibres arise which cross the middle line behind Gudden's commissure and enter the crusta on the opposite side, from whence they are said to pass into the subthalamic body.

The **optic nerve** passes forwards and outwards from the chiasma and enters the orbit through the optic foramen, accompanied by the ophthalmic artery, the vessel being external to and slightly below the nerve. It then slightly changes its direction and passes almost directly forwards to enter the back of the eyeball about three millimetres internal to and slightly below the posterior extremity of the optic axis; having gained the interior of the eyeball its fibres spread out in the retina. In its course through the orbit it is surrounded by the ciliary arteries and nerves; its upper surface is crossed obliquely by the ophthalmic artery and the nasal nerve, and the lenticular ganglion is in contact with its outer surface. Near the optic foramen it is surrounded by, and in close relation to, the four recti muscles; but further forwards it is separated from the muscles by an interval containing fat. The arteria centralis retinæ pierces the under surface of the optic nerve near the middle point of the intraorbital part of its course and thence runs into the eyeball in the axis of the nerve. Very distinct prolongations of the cerebral membranes accompany the optic nerve. The dura mater, having entered the orbit through the optic foramen, delaminates into the orbital periosteum and the sheath of the optic nerve; the latter is tough and strong, and becomes continuous with the sclerotic of the eyeball. Within the dura mater is a narrow subdural space, then the arachnoid and a comparatively wide subarachnoid space, the inner boundary of which is formed by the pia mater, which invests the bundles of nerve-fibres.

THIRD OR OCULO-MOTOR NERVE

The **third** or **oculo-motor nerve** arises from a column of nerve-cells which is placed in the grey matter beneath the floor of the aqueduct of Sylvius immediately dorsal to the posterior longitudinal bundle. This nucleus extends from the level of the posterior commissure to a point corresponding to the interval between the nates and testes, where it is imperfectly separated from the nucleus of the fourth nerve. The fibres arising from it pass downwards and forwards in a series of fasciculi, which traverse the posterior longitudinal bundle, the red nucleus, and the inner part of the substantia nigra, and they emerge (superficial origin) in a row of about nine fasciculi from the oculo-motor groove at the inner side of the crus in the posterior fossa of the skull.

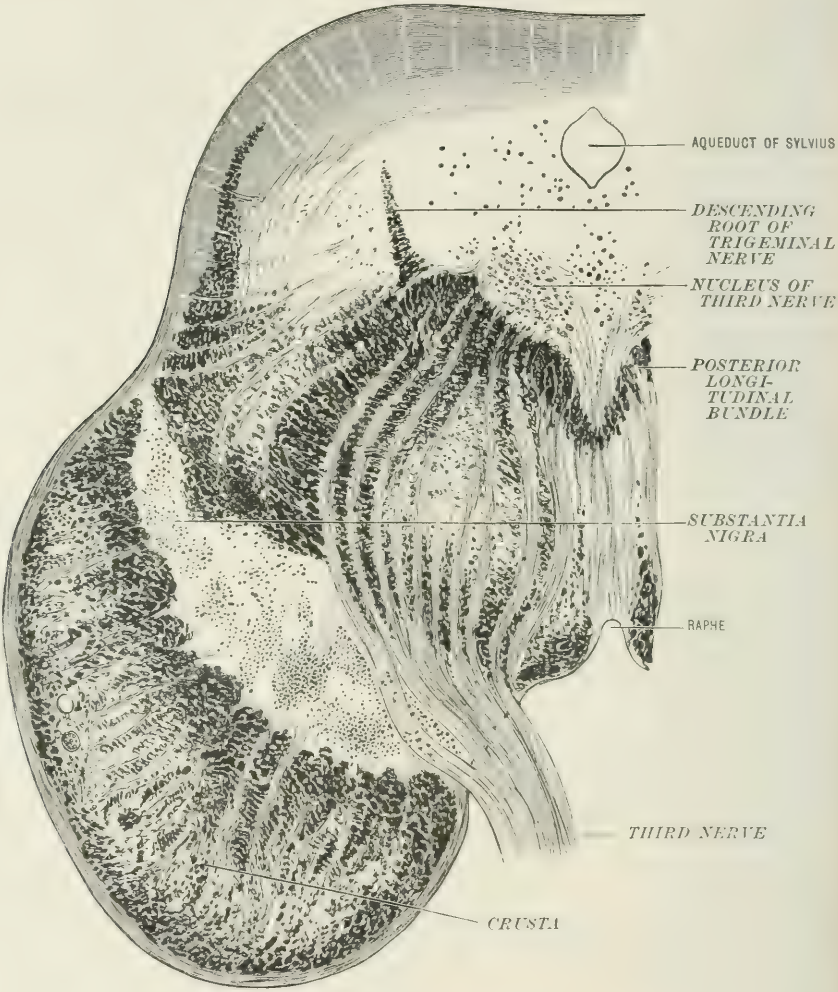
The third nerve passes between the superior cerebellar and posterior cerebral arteries, traverses the aperture in the tentorium, enters the middle fossa of the skull, and then pierces the dura mater about midway between the anterior and posterior clinoid processes of the sphenoid bone in the centre of a little triangular space which has the following boundaries: externally, the free margin of the tentorium cerebelli, posteriorly the attached margin of the tentorium, and internally a ridge of dura mater which extends from the posterior to the anterior clinoid process. It then enters the outer wall of the cavernous sinus and runs forwards to the sphenoidal fissure, occupying, at first, a position superior and internal to the fourth nerve. Behind the sphenoidal fissure it divides into a superior and an inferior division. These divisions, as they enter the orbit through the sphenoidal fissure, pass between the two heads of the external rectus muscle, and are separated from one another by the nasal branch of the ophthalmic division of the fifth nerve.

The **superior division** supplies the superior rectus. It enters that muscle on its ocular surface and sends a branch past its inner border to supply the levator palpebræ superioris.

The **inferior division,** considerably larger than the superior, divides into three branches: two of these, the nerves to the internal and inferior recti muscles, pierce the ocular surfaces of the muscles which they supply. The third branch, the nerve to the inferior oblique, is considerably longer than the other two. It runs forwards in the interval between the inferior and external rectus muscles, and pierces the posterior border of the inferior oblique. Near its commencement it gives off the short or motor root to the lenticular ganglion.

The third nerve supplies all the orbital muscles, with the exception of the external rectus and the superior oblique. It also supplies (through the lenticular ganglion) the ciliary muscle and the circular fibres of the iris (sphincter iridis).

FIG. 443.—DEEP ORIGIN OF THE THIRD NERVE. (After Krause.)


AQUEDUCT OF SYLVIUS
DESCENDING ROOT OF TRIGEMINAL NERVE
NUCLEUS OF THIRD NERVE
POSTERIOR LONGITUDINAL BUNDLE
SUBSTANTIA NIGRA
RAPHE
THIRD NERVE
CRUSTA

In the wall of the cavernous sinus it is connected with the cavernous plexus of the sympathetic and with the ophthalmic division of the fifth.

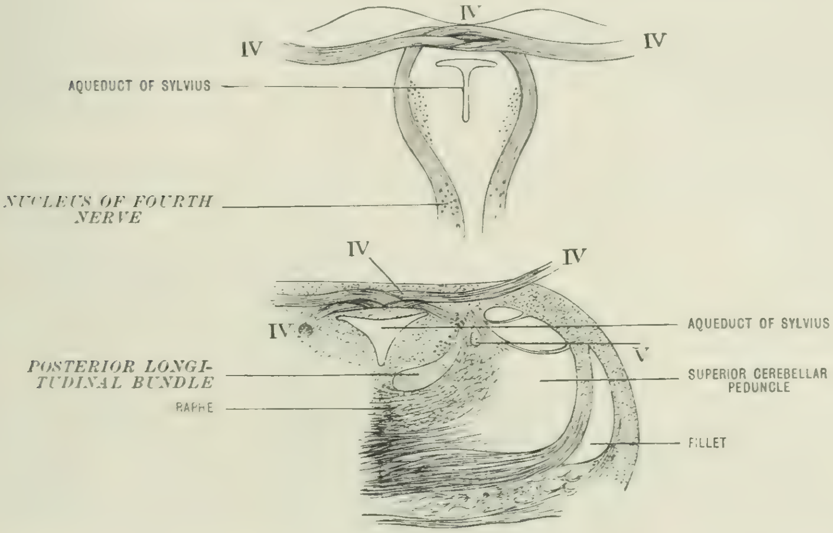
FOURTH OR TROCHLEAR NERVE

The **fourth** or **trochlear nerve** arises from a column of nerve-cells which is continuous with the nucleus of the third nerve. This column of cells is embedded in the central grey matter below the aqueduct, and extends from the level of the interval between the nates and testes to the lower margin of the latter bodies. The nerve-fibres issuing from this elongated nucleus form two or three rounded bundles, which run downwards, backwards, and slightly outwards along the outer side of the nucleus, and then incline inwards to reach the valve of Vieussens, in the substance of which they decussate with their fellows of the opposite side and become collected into a single bundle (fig. 444). This bundle emerges as a slender rounded fasciculus (superficial origin) from the valve of Vieussens, close to the frenulum veli, immediately below the testes, and winds round the crus cerebri to appear at the base of the brain near the anterior margin of the pons. The right nerve, therefore, arises from the left nucleus and *vice versâ*.

The fourth nerve pierces the dura mater at a point a little behind and external to the posterior clinoid process of the sphenoid bone in the posterior fossa of the skull. It runs forwards in the outer wall of the cavernous sinus, being placed between the third nerve, which is above and internal to it, and the ophthalmic division of the fifth nerve, which is situated below and to its outer side. As it approaches the sphenoidal fissure it bends upwards, crosses on the outer side of the third nerve, and passes through the innermost part of the sphenoidal fissure. As it passes through the fissure it is placed above and internal to the frontal nerve. It then passes inwards above the origin of the levator palpebræ superioris muscle, and pierces the orbital surface of the superior oblique muscle, in which it ends.

FIG. 444.—SECTIONS THROUGH THE ORIGIN OF THE FOURTH NERVE. (Stilling.)

(The upper figure is an oblique section, the lower is a coronal section.)



The fourth nerve is the smallest of the cranial nerves. It is remarkable for the length of its intracranial course and for its mode of decussation. Whilst in the wall of the cavernous sinus it is connected with the ophthalmic branch of the fifth nerve and with the cavernous plexus of the sympathetic.

FIFTH OR TRIGEMINAL NERVE

The **fifth** or **trigeminal nerve** consists of two parts, a large sensory root (portio major) and a small motor root (portio minor). The portio major passes into a ganglion (Gasserian ganglion) which has been compared to the ganglion on the posterior root of a spinal nerve, which it probably resembles in exercising a trophic influence on the nerve-fibres, though this has not been experimentally proved. The 'superficial origin' of the nerve is from the side of the pons near its upper border. The deep origin of the **portio major** is chiefly by the **ascending root**, a long tract of fibres which runs for a considerable distance within the cerebro-spinal axis. The portio major has, however, in addition to this, several supplementary origins. The **portio minor** arises principally from a **nucleus** which is embedded in the grey matter of the floor of the fourth ventricle, but it also receives the whole or the greater part of a long tract of fibres, which passes downwards from the mesencephalon, and which is termed the **descending root.**

The majority of the fibres of the portio major spring from the nerve-cells of the Gasserian ganglion; they enter the pons at the base of the middle peduncle and near its upper border. In the substance of the pons they pass backwards and downwards, and the smaller number terminate in arborisations around the cells of the upper sensory nucleus of the fifth nerve, an ovoid group of nerve-cells situated in the upper and lateral part of the floor of the fourth ventricle external to the motor nucleus and continuous below with the substantia gelatinosa Rolandi, which is called the lower sensory nucleus. The greater number of the fibres of the portio major pass downwards in the pons, medulla, and spinal cord, forming a crescentic bundle, known as the ascending root of the fifth nerve, which lies external to the substantia gelatinosa of Rolando. It diminishes in size as it descends, and it finally terminates in the upper part of the cervical region of the cord. Its fibres pass into the substantia gelatinosa and probably terminate in arborisations. In the pons the ascending root of the fifth nerve is deeply placed between the auditory and facial nerve-roots (fig. 430), and in the upper part of the medulla it is covered by the restiform body (fig. 432), but in the lower part of the medulla and the upper part of the cord it lies close beneath the surface.

The **descending root** arises from a column of nerve-cells which is embedded in the grey matter of the aqueduct above and external to the nucleus of the third nerve. The root commences at the level of the upper part of the nates, and increases in size as it descends, forming a white bundle of fibres crescentic in section, some of these fibres being connected with the nerve-cells which are placed on their inner side (fig. 444, v). It passes through the grey matter of the upper part of the floor of the fourth ventricle, close to the outer side of the substantia ferruginea, and reaches the upper part of the motor nucleus of the fifth nerve. Here it is joined by the principal part of the motor root, which arises from the motor nucleus, and by a few fibres from the motor nucleus of the opposite side. It then passes downwards and forwards through the pons to emerge as the portio minor of the fifth nerve. At its emergence it is placed a little in front of the sensory portion, and is separated from the latter by some of the transverse fibres of the pons. The **motor nucleus** is an ovoid mass of cells considerably shorter than the accessory sensory nucleus, on the inner side of which it is placed. It is on the same line as the nucleus of the facial nerve, and is immediately in front of that nucleus.

According to some observers some fibres of the descending root enter the sensory root and are said to eventually pass into the ophthalmic division.

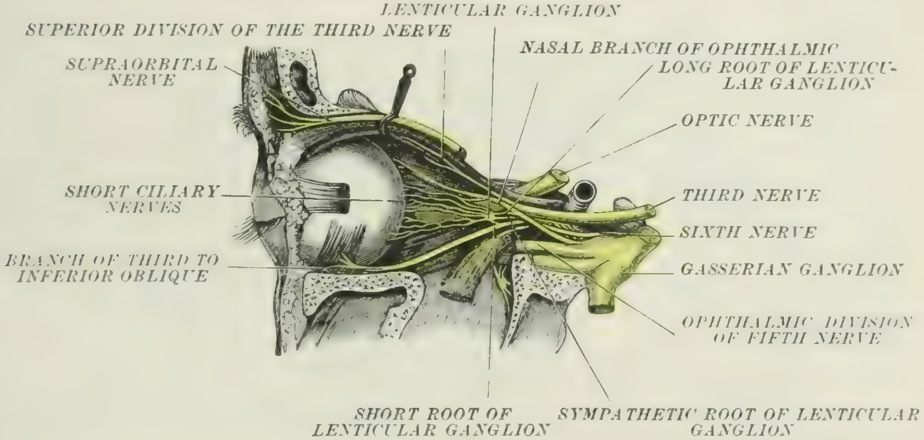
The sensory and motor roots of the nerve pass downwards and forwards towards an aperture in the dura mater which is placed under cover of the tentorium cerebelli, a little external to the apex of the petrous portion of the temporal bone in the posterior fossa of the skull. In this course the motor root takes a half-spiral turn around the sensory root, passing first to the inner side, and then below the latter. Both roots then pass through the aperture above mentioned to enter Meckel's space in the middle fossa, between the supporting and periosteal layers of the dura mater. The motor root passes out of the skull through the foramen ovale, accompanied by a larger sensory bundle from the Gasserian ganglion, and joins with the latter outside the skull to form the mandibular (or inferior maxillary) division of the fifth nerve. The sensory root spreads out into a flattened, somewhat fan-shaped, plexiform bundle, and enters the Gasserian ganglion.

The **Gasserian ganglion** is a reddish-grey band of ganglionic matter, with its long axes slightly curved so as to present a convexity forwards and outwards. The upper and lower surfaces of the ganglion are also slightly convex and are somewhat adherent to the dura mater, the upper surface being more firmly attached than the lower. It rests in a depression on the petrous bone and, in front of this, on the cartilage which occupies the foramen lacerum medium. From the convex antero-external border of the ganglion, three large bundles of nerve-fibres arise. The first or ophthalmic division enters the orbit through the sphenoidal fissure. The second or maxillary (superior maxillary) division leaves the skull through the foramen rotundum. The third division passes through the foramen ovale in front of the motor root of the fifth nerve, with which it unites, as already described, to form the mandibular (inferior maxillary) division. The Gasserian ganglion receives communications from the carotid plexus of the sympathetic, and is said to furnish some minute twigs to the dura mater.

First or Ophthalmic Division of the Fifth Nerve

The **ophthalmic** is the smallest of the three divisions of the fifth, and is entirely sensory in function. It passes forwards and inwards in the outer wall of the cavernous sinus, where it is placed below and external to the fourth nerve. Behind the sphenoidal fissure it divides into three branches. These branches pass through the sphenoidal fissure, piercing the fibrous derivative of the dura mater which closes it. Two of them, the frontal and the lachrymal, enter the orbit above the external rectus muscle. The remaining branch, the nasal, passes between the two heads of that muscle. In its course in the outer wall of the cavernous sinus the ophthalmic division receives communications from the carotid plexus of the sympathetic, and gives off a tentorial branch (nervus recurrens rami primi, Luschka) which runs backwards for a short distance within the sheath of the fourth nerve, and is distributed between the layers of the tentorium cerebelli. It also gives communicating branches to the third, fourth, and sixth nerves. The orbital muscles receive their sensory supply through these communications.

Fig. 445.—Nerves of the Orbit, from the Outer Side.
(From Sappey, after Hirschfeld and Leveillé.)


LENTICULAR GANGLION
SUPERIOR DIVISION OF THE THIRD NERVE
NASAL BRANCH OF OPHTHALMIC
SUPRAORBITAL NERVE
LONG ROOT OF LENTICULAR GANGLION
OPTIC NERVE
SHORT CILIARY NERVES
THIRD NERVE
SIXTH NERVE
BRANCH OF THIRD TO INFERIOR OBLIQUE
GASSERIAN GANGLION
OPHTHALMIC DIVISION OF FIFTH NERVE
SHORT ROOT OF LENTICULAR GANGLION
SYMPATHETIC ROOT OF LENTICULAR GANGLION

(1) The **frontal nerve** is the largest branch of the ophthalmic division. It passes forwards and upwards on the inner side of the third nerve, and enters the orbit immediately external to, and a little below, the fourth nerve. It passes forwards between the periosteum of the orbit and the levator palpebræ superioris muscle, and, a little behind the middle of the orbit, divides into two branches, termed the supraorbital and supratrochlear.

(2) The **supraorbital nerve** leaves the orbit by passing through the supraorbital notch or foramen, where it gives twigs to the upper eyelid, and turns upwards on the frontal bone, accompanied by the supraorbital artery. It divides into two branches, an external and an internal. Both these branches divide into several twigs, which pass very obliquely through the anterior belly of the occipito-frontalis muscle, and supply the integument of the forehead and fore part of the scalp. The **external branch**, which is considerably larger than the internal, may be traced backwards nearly as far as the lambdoidal suture.

(3) The **supratrochlear nerve** is directed forwards and inwards above the pulley of the superior oblique muscle. It communicates with the infratrochlear

branch of the nasal nerve and turns upwards on the forehead, accompanied by the frontal artery. It is much smaller than the supraorbital nerve, and it is distributed to a small area of integument around the glabella. It gives twigs to the inner part of the upper eyelid.

(4) The **lachrymal nerve** is the smallest of the three branches of the ophthalmic division. It passes through the sphenoidal fissure external to and slightly below the frontal nerve, and is directed forwards and outwards along the upper border of the external rectus muscle to the lachrymal gland. Immediately behind the lachrymal gland it communicates with the temporal branch of the orbital nerve, forming a loop convex forwards; from this loop and from the adjacent part of the trunk of the nerve a number of twigs pass into the gland substance. A small twig passes beyond the gland and is distributed to the integument and conjunctiva at the outer canthus of the eye.

(5) The **nasal nerve** enters the orbit by passing forwards between the superior and inferior divisions of the third nerve, and takes an oblique course forwards and inwards to reach the inner wall of the orbit. In this course it passes between the optic nerve and the superior rectus muscle. It then passes between the superior oblique and the internal rectus, traverses the anterior internal orbital canal, accompanied by the anterior ethmoidal vessels, enters the anterior fossa of the skull, crosses the cribriform plate of the ethmoid bone under cover of the dura mater, and enters the nasal fossa through a slit-like aperture at the side of the crista galli (the ethmoidal fissure). It terminates within the nasal fossa by dividing into three branches: an **internal**, or **septal**; an **external**; and an **anterior**, or **terminal.**

Branches.—The **long root to the lenticular ganglion** is given off at the sphenoidal fissure. It is a slender filament which passes forwards to join the upper and back part of the ganglion. The **long ciliary nerves,** usually two in number, arise from the nasal trunk as the latter is crossing the optic nerve. They are directed forwards along the inner side of the optic nerve, and join the lower set of short ciliary nerves after they pierce the sclerotic (page 851). The **infratrochlear nerve** is given off by the nasal just before the latter enters the anterior internal orbital canal. It passes forwards beneath the pulley of the superior oblique muscle, and supplies the skin and conjunctiva around the inner canthus of the eye and the integument of the upper part of the nose. It also supplies the lachrymal sac and caruncle. It communicates with the supratrochlear nerve in front of (sometimes behind) the pulley.

The **internal** or **septal branch of the nasal nerve** runs downwards and forwards on the upper and front part of the nasal septum.

The **external branch** gives two or three twigs to the anterior extremities of the superior and middle turbinated bones, and to the mucous membrane of the outer wall of the nose.

The **terminal** or **anterior branch** runs downwards in a groove on the inner surface of the nasal bone. It pierces the wall of the nose between the nasal bone and the lateral cartilage, and supplies the integument of the lower part of the dorsum of the nose as far as the tip of that organ.

Lenticular Ganglion

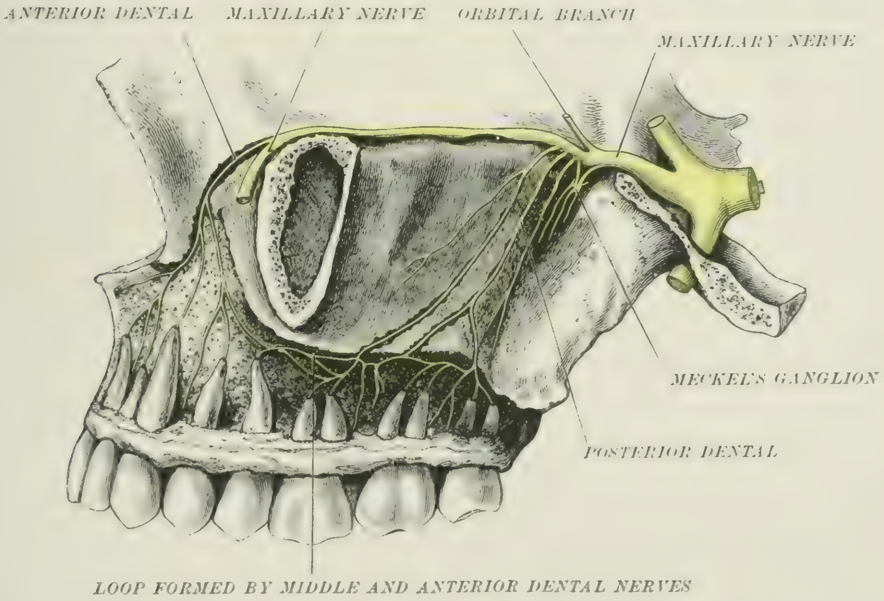
The **lenticular, ciliary,** or **ophthalmic ganglion** is a small reddish-grey body about the size of a pin's head. It is quadrilateral in outline, and its outer and inner surfaces are slightly convex. It is placed between the optic nerve and the external rectus muscle, about a quarter of an inch in front of the sphenoidal fissure. Following the general rule applying to the sporadic ganglia which are connected with the fifth nerve, it is provided with three roots, a motor, a sensory, and a sympathetic. The **motor** or **short root** is derived from the branch of the oculomotor to the inferior oblique muscle; it enters the posterior inferior angle of the ganglion. The **sensory** or **long root** is a branch of the nasal nerve; it passes along the outer side of the optic nerve, and enters the upper and back part of the ganglion. The **sympathetic root** is derived from the cavernous plexus of the sympathetic; it may enter the back part of the ganglion in the form of fine twigs, but usually reaches the ganglion for the most part through the third and nasal nerves, being incorporated with the motor and sensory roots.

From the anterior border of the ganglion about six **short ciliary nerves** arise: these subdivide and communicate with the long ciliary nerves, forming about twenty nerves which separate into a supero-external and an infero-internal group, and surround the optic nerve. The nerves pierce the sclerotic in a circle around the entrance of the optic nerve into the eyeball, and pass forwards between the sclerotic and choroid coats of the eye. They supply nerves of ordinary sensation and trophic nerves to the eyeball (derived from the nasal); the radiating fibres of the iris (derived from the sympathetic); and the ciliary muscle and sphincter of the pupil (derived from the oculo-motor) (page 850).

SECOND OR MAXILLARY DIVISION OF THE FIFTH NERVE

The **maxillary** (**superior maxillary**) **division of the fifth nerve** is intermediate in size between the mandibular (inferior maxillary) and ophthalmic divisions, and, like the latter, it is entirely sensory in function. It proceeds forwards from the Gasserian ganglion for about one-third of an inch within the skull, and then passes through the foramen rotundum. It traverses the upper part of the spheno-maxillary fossa, and, inclining upwards, passes into the orbit through the spheno-maxillary fissure. It then courses forwards along the infraorbital groove, accompanied by the infraorbital artery, to the infraorbital canal, and passes through the canal to emerge at the infraorbital foramen, where it terminates, almost immediately, in three sets of branches, which proceed to the upper lip, the nose, and the lower eyelid.

FIG. 446.—THE MAXILLARY NERVE SEEN FROM WITHOUT. (Beaunis.)



Branches.—The branches of the maxillary division may be classified into four sets, namely:—(1) Intracranial branches; (2) branches which are given off in the spheno-maxillary fossa; (3) branches which arise from the portion of the nerve which is placed in the infraorbital canal; and (4) terminal branches.

The first set (1) consists of one or two **recurrent twigs** to the dura mater, which form loops with the recurrent branch of the mandibular (inferior maxillary) division. The second set (2) comprises the **orbital nerve**, the **spheno-palatine nerves**, and the **posterior superior dental nerves**. (3) The **middle** and **anterior**

superior dental nerves constitute the third set. (4) The **terminal branches** fall into three groups, which are termed labial, nasal, and palpebral branches.

The **orbital** or **temporo-malar nerve** passes upwards and forwards through the spheno-maxillary fissure by which it enters the orbit, and terminates by dividing into two branches, temporal and malar. The **temporal branch** communicates with the lachrymal nerve, and then runs forwards through the periosteum on the outer wall of the orbit, and traverses the spheno-malar foramen. It enters the temporal fossa and pierces the deeper of the two lamellæ of the temporal fascia. It runs outwards for about a quarter of an inch in the fat between the two lamellæ of the fascia, and pierces the superficial lamella about an inch above the superior border of the zygoma; here it forms a well-marked communication with the temporal branch of the facial nerve, and then ramifies in the integument of the anterior temporal region. The **malar branch** (**ramus subcutaneous malæ**) runs forwards in the loose fatty tissue of the orbit, and passes through the malar foramen. It pierces the orbicularis palpebrarum and supplies a small area of skin over the prominence of the cheek. It communicates with the malar branch of the facial nerve.

The **spheno-palatine nerves** are two stout twigs which pass downwards to Meckel's ganglion, of which they form the sensory roots; most of the nerve-fibres pass on the inner side of the ganglion without traversing the ganglionic substance, but it is more convenient to trace these nerves with the branches of the ganglion.

The **posterior superior dental nerves,** usually two in number, pass downwards and outwards through the pterygo-maxillary fissure. They furnish several twigs to the gums (**nervuli gingivales**) and adjacent part of the mucous membrane of the cheek. They then enter foramina in the maxilla, follow the curve of the alveolar arch through minute canals in the bone above the roots of the molar teeth, and end by communicating in a plexiform manner with the middle dental nerve. They give off minute branches to the mucous membrane of the antrum, and furnish three twigs to each of the molar teeth. These twigs enter the foramina at the tips of the fangs of the teeth and ramify in the pulp.

The **middle** and **anterior superior dental nerves** are small branches which pass through canals in the substance of the maxilla to supply the incisor, canine, and bicuspid teeth and the corresponding regions of the gums. In the upper, and more particularly in the lower, parts of these canals the nerves are surrounded on all sides by thick bone; but in the middle part, where they are traversing the anterior wall of the antrum, they are surrounded by a mere shell of bone, which is not infrequently deficient on the deep surface, so that the nerves may lie in grooves in the anterior wall of the antrum between the bone and mucous membrane. In this situation the nerves furnish twigs to the antrum. The **middle dental nerve** enters a foramen at the posterior part of the infraorbital canal. It supplies the bicuspid teeth, and communicates with the anterior and posterior dental nerves. It may be wanting. The **anterior dental nerve** enters a canal close to the infraorbital foramen, and supplies the incisor and canine teeth. It gives off a **nasal branch,** which passes through a minute canal in the bone and enters the anterior part of the inferior meatus. Here it ramifies in the mucous membrane, and communicates with the naso-palatine nerve from Meckel's ganglion. It communicates with the middle dental nerve.

Two small gangliform enlargements are occasionally found on the plexiform arch formed by the dental nerves. One of these, the **ganglion of Valentin,** is situated above the root of the second bicuspid at the junction of the middle and posterior dental nerves. The other, the **ganglion of Bochdalek,** is placed on the junction of the anterior and middle dental nerves.

The **labial branches,** usually four in number, are the largest of the three terminal divisions of the maxillary nerve. They pass downwards, spreading out as they descend, under cover of the levator labii superioris muscle, and ramify in the structures forming the upper lip, very large twigs being supplied to the mucous membrane.

The **nasal branches,** three or four in number, are intermediate in size. They pass inwards under cover of the levator labii superioris alæque nasi, and supply the integument on the lateral aspect of the nose.

The **palpebral branches,** the smallest of the terminal divisions of the nerve, pierce the origin of the levator labii superioris, and turn upwards around the lower border of the orbicularis palpebrarum. They are usually two in number, an external and an internal; they ramify in the integument of the lower eyelid.

The terminal branches of the maxillary division communicate freely with the infraorbital branch of the facial, forming the **infraorbital plexus.** The plexus is placed under cover of the levator labii superioris.

MECKEL'S GANGLION

The **spheno-palatine, nasal,** or **Meckel's ganglion** is a small reddish-grey body which is situated in the spheno-maxillary fossa. It is triangular in form, flattened at the sides, and measures about one-fifth of an inch in its longest diameter. It is provided with three roots, a motor and a sympathetic, which reach it through the Vidian nerve, and a sensory root from the maxillary nerve. The latter root is in the form of two stout twigs, which are described as the spheno-palatine nerves.

Roots.—The **great superficial petrosal nerve** is the motor root of the ganglion. It arises from the geniculate ganglion of the facial nerve within the aqueduct of Fallopius, and enters the cranial cavity by traversing the hiatus Fallopii. It then runs forwards and inwards in a groove in the petrous portion of the temporal bone, and, after passing under the Gasserian ganglion, enters an oblique canal in the cartilage which occupies the foramen lacerum medium. Having reached the posterior opening of the Vidian canal, it unites with the great deep petrosal nerve to form the Vidian nerve.

The **great deep petrosal nerve** is of a grey colour and is soft in consistence. It arises from the carotid plexus of the sympathetic close to the intracranial termination of the carotid canal, traverses a canal in the cartilage, which occupies the foramen lacerum medium, and joins the Vidian nerve.

The **Vidian nerve** runs forwards through the canal of the same name, accompanied by the Vidian artery, and enters the spheno-maxillary fossa, where it ends in the posterior angle of Meckel's ganglion. While within the canal the Vidian nerve furnishes **nasal twigs** to the mucous membrane of the posterior part of the roof of the nose. They may be regarded as superior nasal nerves, which, after leaving Meckel's ganglion, have become associated with the Vidian nerve for a part of their course.

Branches.—The branches of Meckel's ganglion are classified into (1) **ascending,** to the orbit; (2) **internal,** to the mucous membrane of the nose; (3) **descending,** to the hard and soft palate; and (4) **posterior,** to the pharynx.

(1) **Ascending branches.**—The **ascending** or **orbital branches** are two or three small twigs which enter the orbit through the spheno-maxillary fissure, and proceed within the periosteum to the inner wall of the orbit, where they pass through the posterior internal orbital canal and through the foramina in the suture behind that canal to be distributed to the mucous membrane which lines the posterior ethmoidal cells and the sphenoidal sinus.

(2) **Internal branches.**—The internal branches are derived in part from the inner side of the ganglion, but are also largely made up of fibres which pass from the spheno-palatine nerves without traversing the ganglionic substance. They are disposed in two sets, the superior nasal and the septal.

The **superior nasal** are six or seven small twigs which pass through the spheno-palatine foramen, and are distributed to the mucous membrane covering the posterior parts of the superior and middle turbinated bones. They also furnish twigs to the lining membrane of the posterior ethmoidal cells.

The **septal branches** are two or three in number, and pass inwards through the spheno-palatine foramen. They cross the roof of the nasal fossa to reach the back part of the nasal septum, where the smaller twigs terminate. The largest nerve of the set, **naso-palatine nerve,** or **nerve of Cotunnius,** runs downwards and forwards in a groove in the vomer between the periosteum and the mucous membrane to the anterior palatine canal. Here it communicates with the nasal branch of the anterior superior dental nerve. The two naso-palatine nerves then pass through the foramina of Scarpa in the intermaxillary suture, the left nerve passing through the anterior of the two foramina. In the lower part of the anterior palatine canal the two nerves form a plexiform communication (formerly described as Cloquet's ganglion) and furnish twigs to the anterior part of the hard palate. In this situation they communicate with the anterior palatine nerves.

(3) **Descending branches.**—The descending branches are the great or anterior, the posterior, and the external palatine nerves. Like the internal set of branches, they are in part derived from the ganglion and in part directly continuous with the spheno-palatine nerves.

The **great** or **anterior palatine** nerve arises from the inferior angle of Meckel's ganglion, and passes downwards through the posterior palatine canal, accompanied by the descending palatine artery. Emerging from the canal, it divides into two or three branches, which pass forwards in grooves in the hard palate and supply the glands and mucous membrane of the hard palate and the gums on the inner aspect of the alveolar border of the upper jaw. During its course through the posterior palatine canal, the anterior palatine nerve gives off, usually two, **inferior nasal nerves.** These nerves pass through small openings in the perpendicular plate of the palate bone to supply the mucous membrane covering the back parts of the inferior turbinated bone and lining the middle and inferior meatuses of the nose.

The **posterior** or **small palatine nerve** passes downwards through the accessory palatine canal, and enters the soft palate, distributing branches to that organ, to the uvula, and to the tonsil. It was formerly believed to convey motor fibres from the facial nerve to the levator palati and azygos uvulæ muscles, but these muscles are now known to be supplied by the spinal accessory nerve, through the pharyngeal plexus.

The **external palatine nerve,** the smallest of the three, traverses the external palatine canal, and supplies twigs to the tonsil and to the adjacent part of the soft palate.

(4) **Posterior branch.**—The Vidian is considered by some anatomists to be a branch, in which case it would be classed here. We have, however, regarded it as the united motor and sympathetic root of the ganglion; therefore, the pharyngeal branch only remains to be described.

The **pharyngeal branch** is of small size, and passes backwards and somewhat inwards through the pterygo-palatine canal, accompanied by the pterygo-palatine artery. It is distributed to the mucous membrane of the uppermost part of the pharynx, to the upper part of the posterior nares, to the opening of the Eustachian tube, and to the lining of the sphenoidal sinus.

Third or Mandibular Division of the Fifth Nerve

The **mandibular** (**inferior maxillary**) **division** is the largest of the three divisions of the fifth nerve, and is formed, as before stated, by the union of two distinct parts, namely, the entire motor root of the fifth nerve and a large bundle of fibres derived from the sensory root and traversing the Gasserian ganglion. These two parts pass through the foramen ovale and unite immediately outside the skull to form a large trunk which terminates almost directly after its formation by dividing into a smaller anterior and a larger posterior portion. The anterior portion is chiefly motor, and the posterior division mainly sensory in function. Previous to its division, two branches arise from the trunk of the nerve, namely, the recurrent nerve and the nerve to the internal pterygoid.

(1) The **recurrent nerve** enters the cranium through the foramen spinosum, accompanying the middle meningeal artery, and divides into an anterior and a posterior branch. The anterior branch communicates with the meningeal branch of the maxillary division of the fifth nerve, furnishes filaments to the dura mater, and ends in the osseous substance of the great wing of the sphenoid. The posterior branch traverses the petro-squamous suture and ends in the lining membrane of the mastoid cells.

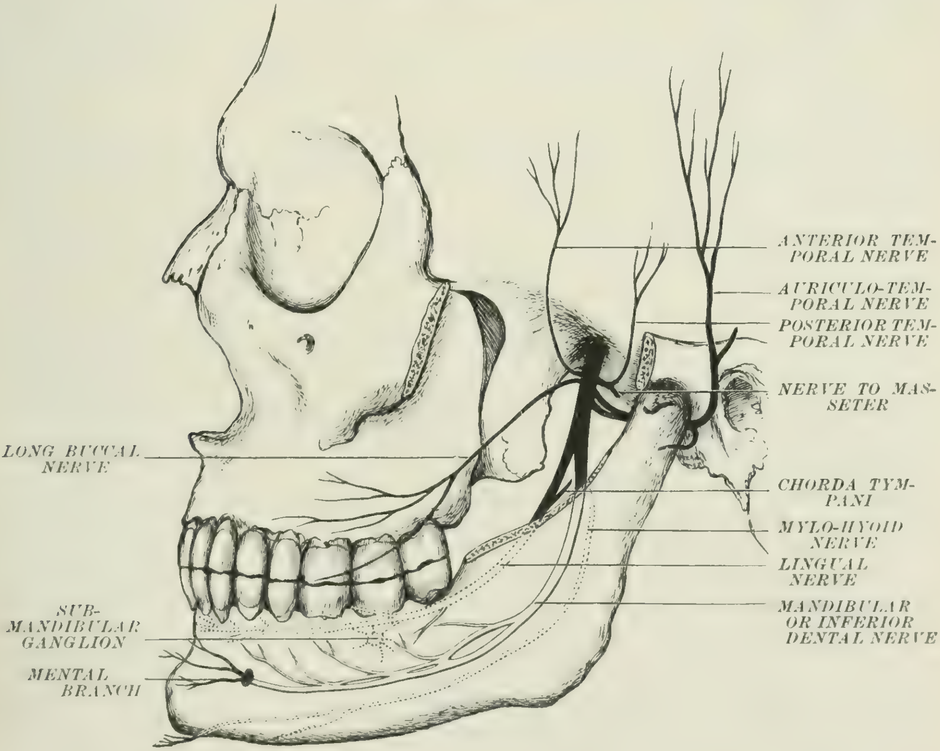
(2) The **nerve to the internal pterygoid** passes under cover of a dense layer of fascia derived from an expansion of the ligamentum pterygo-spinosum, and enters the deep surface of the muscle. Near its commencement this nerve furnishes a motor root to the otic ganglion.

The **ANTERIOR PORTION** of the mandibular division of the fifth nerve supplies the temporal, masseter, and external pterygoid muscles, and gives off a sensory branch, the long buccal nerve; the latter is accompanied, in the first part of its course, by a small strand of motor fibres which leaves it to end in the anterior part of the temporal muscle.

(1) The **temporal nerves,** usually two in number, pass between the bone and the upper border of the external pterygoid muscle, and turn upwards around the infra-temporal crest of the sphenoid bone to end in the deep surface of the temporal muscle. The posterior of these two nerves may arise in common with the masseteric nerve.

(2) The **masseteric nerve** passes between the bone and the external pterygoid muscle external to the temporal nerves, and accompanies the masseteric artery through the sigmoid notch of the mandible to be distributed to the masseter. It may be readily traced through the deeper fibres of the masseter nearly to the anterior border of that muscle. As it emerges from under cover of the external pterygoid it gives a twig to the temporo-mandibular articulation.

FIG. 447.—DISTRIBUTION OF THE MANDIBULAR DIVISION OF THE TRIGEMINAL NERVE. (Henle.)


ANTERIOR TEMPORAL NERVE
AURICULO-TEMPORAL NERVE
POSTERIOR TEMPORAL NERVE
NERVE TO MASSETER
LONG BUCCAL NERVE
CHORDA TYMPANI
MYLO-HYOID NERVE
LINGUAL NERVE
MANDIBULAR OR INFERIOR DENTAL NERVE
SUB-MANDIBULAR GANGLION
MENTAL BRANCH

(3) The **nerve to the external pterygoid,** after a course of about an eighth of an inch, divides into twigs which enter the deep surface of the two heads of the muscle. It is usually adherent at its origin to the long buccal nerve.

(4) The **long buccal nerve** passes between the two heads of the external pterygoid muscle, and then turns forwards and emerges from under cover of the temporal and masseter muscles at the anterior border of the latter. It runs forwards and communicates with the buccal branch of the facial, being in this situation covered only by the integument and fascia, to which it gives branches; then it pierces the buccinator muscle and ramifies in the mucous membrane lining the cheek, its terminal twigs reaching as far forwards as the angle of the mouth. As it emerges

from between the heads of the external pterygoid, it gives off a slender twig to the temporal muscle.

The **POSTERIOR PORTION** of the mandibular division of the fifth nerve divides into three large branches; two of these, the auriculo-temporal and the lingual, are exclusively sensory; the remaining branch, mandibular (inferior dental), contains a strand of motor fibres—the mylo-hyoid nerve.

(1) The **auriculo-temporal nerve** arises by two roots, which usually embrace the middle meningeal artery, and passes backwards and outwards between the internal lateral ligament of the temporo-mandibular articulation and the condyle of the mandible, closely embracing the capsular ligaments of the joint. It then ascends under cover of the parotid gland and traverses the glandular substance as it crosses the root of the zygoma. It accompanies the temporal artery, being placed under cover of and slightly behind that vessel, and terminates at the level of the tragus of the ear by dividing into auricular and temporal branches. As it passes through the parotid gland it communicates with the temporo-facial division of the facial nerve by two stout twigs, which may surround the temporal artery. The auriculo-temporal nerve receives communicating twigs from the otic ganglion, and gives off the articular branch, the nerves to the meatus, and the parotid branches. It terminates in the anterior auricular and superficial temporal branches.

(*a*) The **communicating twigs from the otic ganglion** join the nerve close to its commencement in the form of several fine filaments.

These filaments have been shown by physiological experiments to be derived from the glosso-pharyngeal nerve through the lesser superficial petrosal. They run for a short distance in the trunk of the auriculo-temporal, and leave it under the name of parotid branches. They are the secreto-motor fibres of the parotid gland.

(*b*) The **articular branch** is supplied to the temporo-mandibular articulation as the auriculo-temporal nerve is passing between the capsular ligament and the parotid gland.

(*c*) The **nerves to the meatus,** two in number, pass between the bony and cartilaginous parts of the external auditory meatus and supply the skin lining the meatus. The upper of the two nerves furnishes a filament to the upper and anterior part of the membrana tympani. The lower nerve gives twigs to the lobule of the ear. Occasionally only the upper nerve is present, the lower being replaced by a twig from the great auricular. (Henle.)

(*d*) The **parotid branches** are a variable number of fine twigs which arise either directly from the auriculo-temporal nerve or from the loops of communication between it and the facial. As above mentioned, they supply the glandular substance.

(*e*) The **anterior auricular branches,** two in number, are supplied to the upper part of the pinna, and are chiefly distributed to the integument which covers the anterior aspect of the tragus and helix.

(*f*) The **superficial temporal branches** divide at acute angles and ramify over the integument which covers the temporal fascia. The largest twig accompanies the posterior branch of the temporal artery. The anterior twigs communicate with the temporal branches of the facial nerve.

(2) The **mandibular (inferior dental) nerve** is the largest branch of the mandibular division. It passes downwards under cover of the external pterygoid muscle to reach the interval between the ramus of the lower jaw and the spheno-mandibular ligament. In this situation it is placed on the outer side of and somewhat behind the lingual nerve, and is connected to the latter by a transverse communicating branch. It then enters the mandibular canal accompanied by the mandibular artery, and lies at first behind and then below that vessel as it follows the course of the canal. Opposite the mental foramen it terminates by dividing into an incisive and a mental branch. The branches of the inferior dental nerve are the mylo-hyoid, the alveolar, the incisive, and the mental.

(*a*) The **mylo-hyoid** is given off from the mandibular nerve immediately before the latter enters the dental canal. It runs downwards and forwards in the mylo-hyoid groove of the mandible between the bone and the internal pterygoid muscle. In this course it is accompanied by the mylo-hyoid artery. It then runs forwards on the inferior surface of the mylo-hyoid muscle, under cover of the submaxillary gland and, after supplying the muscle with several twigs, it pierces the anterior belly of the digastric, in the substance of which it ends.

(*b*) The **alveolar branches** are a series of twigs which are given off within the mandibular canal to supply the molar and bicuspid teeth. They communicate with one another within the bone, forming a fine plexus. From this plexus twigs are given off corresponding in number to the fangs of the teeth; they enter the minute apertures at the tips of the fangs and end in the pulp. Twigs are also given to the adjacent part of the gums (**nervi gingivales**).

(*c*) The **incisive branch,** the smaller of the two terminal divisions, is continued forwards and inwards in the dental canal, and supplies the canine and incisor teeth and the corresponding region of the gums.

(*d*) The **mental branch** is a nerve of considerable size which emerges through the mental foramen. It communicates, near its exit, with the supramandibular branch of the facial nerve, and then divides into three branches. The smallest branch turns downwards to supply the chin. The other two pass upwards, diverging as they ascend, and divide into a number of twigs. The stoutest twigs ramify upon the mucous membrane which lines the lower lip. Other twigs are distributed to the integument and fascia of the lip and chin.

(3) The **lingual** (formerly called **gustatory**) **nerve** is slightly smaller than the mandibular nerve, and is placed at first in front of and close to the inner side of the latter under cover of the external pterygoid muscle. In this situation it is joined by the chorda tympani nerve; the latter enters the lingual on its outer side, the two nerves uniting at an acute angle. The lingual then escapes from under cover of the external pterygoid muscle, and is connected to the mandibular nerve by a transverse communicating branch. It then passes between the ramus of the mandible and the internal pterygoid muscle, and is continued forwards between the mucous membrane of the mouth and the mylo-hyoid muscle, and lies on the origin of this muscle close to the bone. In this part of its course it can be easily divided by an incision through the mucous membrane at the level of the second lower molar tooth. It then runs between the mylo-hyoid and hyo-glossus muscles, crosses below Wharton's duct, and finally courses forwards by the side of the tongue, so as to reach the tip of that organ. As it crosses the hyo-glossus muscle it forms a curve with the convexity directed downwards, and is connected at the most dependent part of the curve to the submandibular (submaxillary) ganglion, to which it furnishes sensory roots. Immediately beyond the ganglion it communicates freely with the hypoglossal nerve, the communications forming several loops.

Branches.—(*a*) Communicating branches are given to the mandibular nerve, to the submaxillary ganglion, and to the hypoglossal nerve. These have already been described.

(*b*) Twigs are distributed to the interval between the tongue and gums, and ramify in the mucous membrane of the floor of the mouth.

(*c*) A twig enters the sublingual gland. This twig conveys secreto-motor fibres from the chorda tympani to the gland.

(*d*) The lingual branches are a series of twigs which are given off by the lingual nerve in the last stage of its course as it is passing forwards towards the tip of the tongue. They pierce the musculature at the side of the tongue, and proceed to the dorsum of the middle and anterior part of that organ, where they end in the filiform and fungiform papillæ.

SUBMANDIBULAR (SUBMAXILLARY) GANGLION

The **submandibular ganglion** is a small reddish fusiform body which is placed between the mylo-hyoid and hyo-glossus muscles above Wharton's duct. It is connected with the lingual nerve by two communications, an anterior and a posterior. The posterior communication contains the motor and sensory roots of the ganglion. The anterior communication represents a branch passing from the ganglion to the lingual nerve. The motor root is derived from the chorda tympani. The sensory root is furnished by the lingual. The ganglion also receives a sympathetic root from the plexus of the sympathetic which accompanies the facial artery.

Branches.—The ganglion furnishes five or six twigs to the submandibular (submaxillary) gland, and gives minute twigs to Wharton's duct, which accompany the duct to its termination. From the fore part of the ganglion a branch passes to the lingual nerve, and through this branch fibres from the chorda tympani are conveyed to the sublingual gland and to the tongue.

Sublingual ganglion.—A small ganglion has been described by Blandin and others on the twig to the sublingual gland. According to Bose, it is not constant.

OTIC GANGLION

The **otic ganglion, or ganglion of Arnold,** is a small reddish-grey body which is placed immediately below the foramen ovale, internal to the mandibular division of the trigeminal nerve. The cartilage of the Eustachian tube and the tensor tympani muscle are placed close to its inner side, and the middle meningeal artery is behind it. The ganglion is oval in form, and compressed in its coronal diameter. It is greatest in its sagittal diameter, which is about four millimetres.

Roots.—The mandibular division of the trigeminal nerve supplies one or more roots to the otic ganglion; these roots probably contain both sensory and motor fibres, and are associated with the nerve to the internal pterygoid. The lesser superficial petrosal nerve enters the ganglion, being a **motor root.** The ganglion receives a **sympathetic root** from the plexus which surrounds the middle meningeal artery.

Branches.—The otic ganglion furnishes muscular twigs to the tensor palati and tensor tympani; these twigs, especially the former, pass for the most part from the mandibular division of the fifth nerve to the muscles without interruption in the nerve-cells of the ganglion. It also gives communicating branches to the auriculo-temporal, the chorda tympani, and to the Vidian nerves.

SIXTH OR ABDUCENT NERVE

The **sixth** or **abducent nerve** arises from an approximately spherical cluster of nerve-cells which is placed between the grey matter of the floor of the fourth ventricle and the formatio reticularis. This nucleus is situated near the middle line, a little in front of the striæ acusticæ, and corresponds to the eminentia teres. It is on a line with the nuclei of the third and fourth nerves. The fibres which arise from it plunge forwards and downwards through the substance of the pons, and emerge at the lower border of the latter structure (superficial origin). Some of the fibres pass through the pyramidal body; others pass out in the interval between the latter and the olivary body.

The sixth nerve was formerly described as giving fibres of origin to the facial, but Gudden and Gowers have shown that this is not the case. A remarkable strand of fibres passes from the abducens nucleus to the posterior longitudinal bundle. It runs brainwards, forming the inner border of the bundle, and decussates below the corpora quadrigemina with its fellow of the opposite side; it then joins the third nerve, and passes eventually into the internal rectus muscle. Thus the eyes can be directed to the right or left, as the case may be, by the action of a single nucleus, e. g. in turning the eyes to the right, the **right** external rectus and the **left** internal rectus are used, and these are both supplied by the right abducens nucleus.

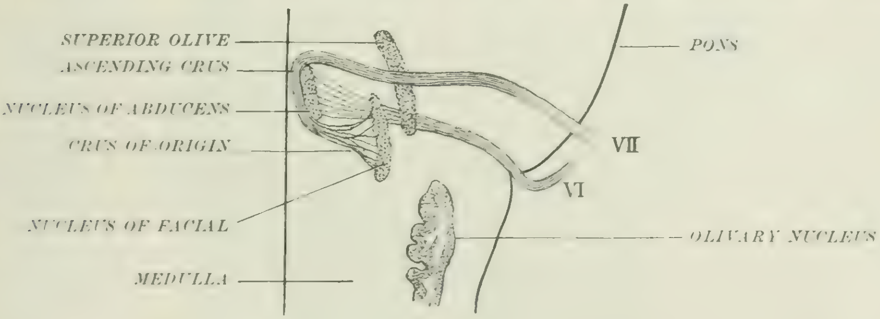
The sixth nerve pierces the dura mater at a point a little above the junction of the basilar process of the occipital bone with the sphenoid. It runs upwards between the pons and the body of the sphenoid and at the side of the basilar artery, and turns forwards in the interval between the apex of the petrous portion of the temporal bone and the posterior clinoid process of the sphenoid, passing in this situation under cover of a ligament which connects the osseous prominences above mentioned. It enters the floor of the cavernous sinus, and passes on to the outer side of the internal carotid artery. In this situation it receives several communications from the carotid plexus of the sympathetic. It enters the orbit through the sphenoidal fissure, passing between the inferior division of the third nerve and the ophthalmic vein, in the interval between the two heads of the external rectus muscle, and ends by piercing the ocular surface of that muscle.

SEVENTH OR FACIAL NERVE

The **seventh** or **facial nerve** is formed by two distinct parts—the main trunk, or facial nerve proper, and an accessory portion, the pars intermedia of Wrisberg. The **facial nerve** proper arises from an elongated nucleus which is deeply placed in the reticular formation of the pons below the floor of the fourth ventricle. This nucleus commences at the level of the striæ acusticæ, and extends brainwards for about four millimetres. The fibres which arise from it pursue a remarkably tortuous course within the substance of the pons. At first they pass backwards and inwards so as to approach the ependyma of the floor of the fourth ventricle close to the sulcus longitudinalis medianus (**crus of origin**). They then run upwards and forwards in a compact bundle (**fasciculus teres,** or **ascending crus**), which produces an elevation (**eminentia teres**) on the floor of the fourth ventricle immediately external to the median fissure. The bundle of fibres then bends, and is directed at right angles to its former course; it arches outwards over the nucleus of the sixth nerve, and passes forwards, outwards, and downwards (**issuing crus**). In this part of its course it passes to the outer side of its own nucleus, between the latter and the ascending root of the fifth nerve. Finally it emerges at the lower border of the pons in the interval between the olivary and restiform bodies (superficial origin).

From the above description, it will be seen that the facial nerve embraces the nucleus of the abducens; the term **genu nervi facialis internus** is applied to the nerve in this part of its course. Within the substance of the pons the issuing root of the facial nerve is joined by fibres from the oculo-motor and hypoglossal nuclei which pass to it by means of the posterior longitudinal bundle. The fibres from the oculo-motor nucleus are distributed by the temporal branches of the facial nerve to the corrugator supercilii, the upper part of the orbicularis palpebrarum and to the frontalis muscles, whilst the fibres received from the hypoglossal are said to supply the orbicularis oris.

FIG. 448.—DIAGRAMMATIC LATERAL VIEW OF THE ORIGIN OF THE FACIAL NERVE. (Krause.)



The **pars intermedia of Wrisberg** arises from the extreme upper (proximal) end of the sensory nucleus of the glosso-pharyngeal nerve (Duval).[1] Its fibres pass obliquely through the substance of the pons, and emerge at the lower border of the last-named structure immediately external to the facial nerve, between the latter and the auditory nerve (superficial origin). Thence the nerve passes, in the form of a small compact bundle, and enters the internal auditory meatus. In this situation it lies on the upper surface of the auditory nerve, while the facial is placed above it. It joins the facial nerve at the commencement of the geniculate ganglion.

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[1] This nerve is regarded as an aberrant fasciculus of the glosso-pharyngeal nerve, and additional support is given to this view by the fact that it also receives fibres from the funiculus solitarius (Testut). The chorda tympani is usually regarded as the continuation of it, and thus the anterior part of the tongue receives fibres from the glosso-pharyngeal through the chorda

tympani, while the posterior part of the organ is supplied directly. (See GLOSSO-PHARYNGEAL NERVE.)

At its superficial origin the facial nerve is placed immediately internal to the auditory nerve, the pars intermedia of Wrisberg intervening between them. As the facial nerve enters the internal auditory meatus, it is placed above the auditory nerve. It then parts company with the auditory nerve by entering the aqueduct of Fallopius. While traversing the aqueduct, it necessarily follows the windings of that canal. It passes at first outwards and forwards through the bone above and between the cochlea and the vestibule. It then makes a sharp bend, and runs backwards and slightly downwards, being separated from the tympanum in this part of its course only by a very thin scale of bone and by the mucous membrane lining the cavity. Lastly, it runs directly downwards, and emerges at the stylo-mastoid foramen. The portion of the nerve corresponding to the first bend is considerably thickened, and contains some nerve-cells; it is called the **geniculate ganglion.** The ganglionic substance forms a little conical cap on the bend of the nerve, the apex of the cone being directed towards the hiatus Fallopii.

After its emergence from the stylo-mastoid foramen, the facial nerve runs downwards and forwards within the substance of the parotid gland, and terminates by dividing into two divisions—an upper or temporo-facial, and a lower or cervico-facial.

The **branches** of the facial nerve may be classified into three sets:—(1) Branches given off within the aqueduct of Fallopius; (2) branches from the extracranial portion of the nerve before its terminal division; (3) branches of the temporo-facial and cervico-facial divisions.

(1) Six branches are given off within the aqueduct: viz. three from the geniculate ganglion, the great, the lesser, and the external superficial petrosal nerves; and three from the facial nerve in the descending part of its course—viz. the nerve to the stapedius, the chorda tympani, and a communicating twig to the pneumogastric.

(*a*) The **great superficial petrosal nerve** receives a communicating filament from the tympanic branch of the glosso-pharyngeal, and leaves the aqueduct by passing through the hiatus Fallopii. It runs forwards and inwards in a groove on the petrous portion of the temporal bone under cover of the dura mater. It passes beneath the Gasserian ganglion, and pierces obliquely the cartilaginous substance which occupies the foramen lacerum medium; here it is joined by the great deep petrosal nerve, and forms, with the latter, the Vidian nerve as already described.

(*b*) The **lesser superficial petrosal nerve** arises from the geniculate ganglion external to the preceding. It receives a relatively large communication from the tympanic branch of the glosso-pharyngeal. This communication is often considered to be the main root of the nerve (Schwalbe and others). It leaves the aqueduct through a canal which is placed external to the hiatus Fallopii, and passes forwards for a short distance, lying in a groove in the bone, under cover of the dura mater. It escapes from the cranium through a small foramen situated between the foramen ovale and the foramen spinosum (canalis innominatus), and enters the otic ganglion. Occasionally it leaves the skull by traversing the suture between the great wing of the sphenoid and the petrous portion of the temporal bone, or by passing through the foramen ovale.

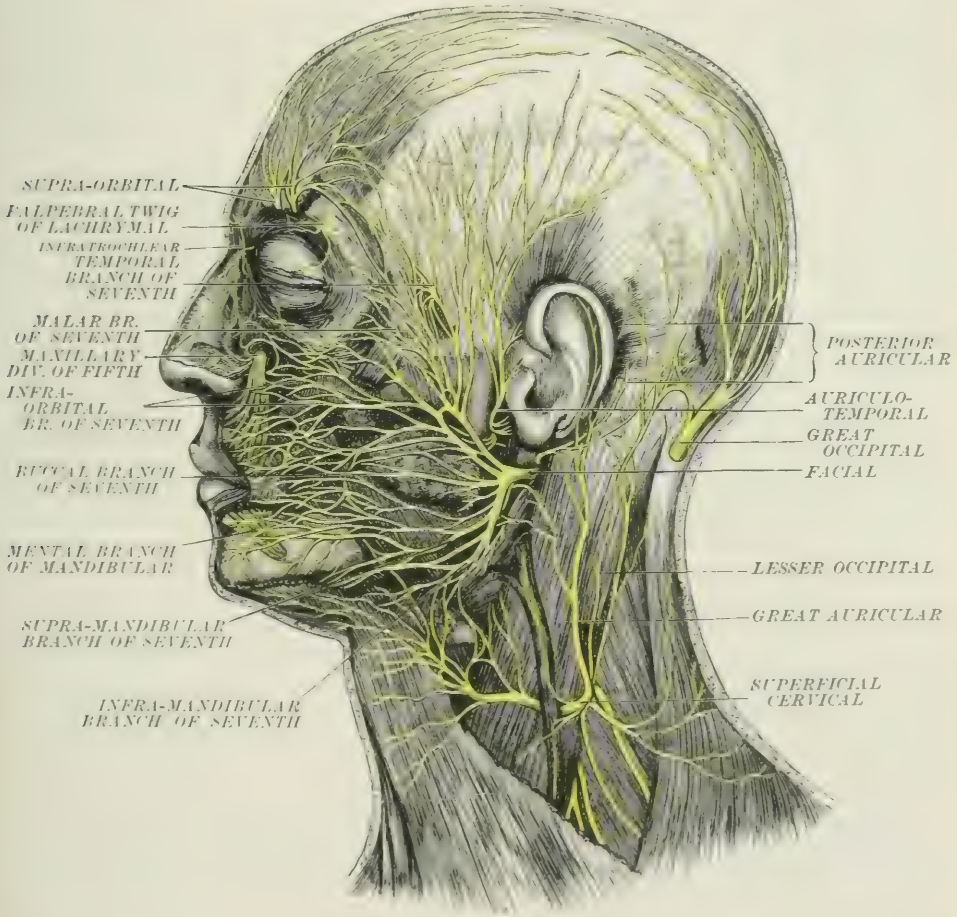
(*c*) The **external superficial petrosal** is the smallest of the three petrosal nerves. It passes through a minute canal in the temporal bone immediately external to the point of emergence of the lesser superficial nerve. It then runs forwards, under cover of the dura mater, and joins the plexus of the sympathetic on the middle meningeal artery close to the foramen spinosum.

(*d*) The **nerve to the stapedius** is a minute twig which is given off by the facial nerve immediately below the second bend which the nerve forms within the aqueduct. It passes through a small canal leading from the aqueduct to the interior of the pyramid, and ends in the muscular substance of the stapedius.

(*e*) The **chorda tympani** arises from the facial nerve about five millimetres above the stylo-mastoid foramen. It pursues a slightly recurrent course, upwards and forwards, through the iter chordæ posterius, and thus enters the tympanum.

It crosses the membrana tympani at the junction of the upper and middle thirds of that membrane. In this part of its course it runs forwards between the fibrous and mucous layers of the membrana tympani, passing on the inner side of the manubrium of the malleus. It leaves the tympanum by passing through the iter chordæ anterius, or canal of Huguier, crosses the inner side of the spine of the sphenoid in the groove described by Mr. Lucas, and, after communicating with the otic ganglion, passes forwards, under cover of the external pterygoid muscle, to gain the outer side of the lingual nerve, which it joins at an acute angle. Thence it runs in the sheath of the lingual nerve, a portion of its fibres, as already described (see LINGUAL NERVE), passing into the submandibular ganglion. Other fibres reach the sublingual gland, and the dorsum of the tongue.

FIG. 449.—SUPERFICIAL DISTRIBUTION OF THE FACIAL AND OTHER NERVES OF THE HEAD. (After Hirschfeld and Leveillé.)


SUPRA-ORBITAL
PALPEBRAL TWIG OF LACHRYMAL
INFRATROCHLEAR
TEMPORAL BRANCH OF SEVENTH
MALAR BR. OF SEVENTH
MAXILLARY DIV. OF FIFTH
INFRA-ORBITAL BR. OF SEVENTH
BUCCAL BRANCH OF SEVENTH
MENTAL BRANCH OF MANDIBULAR
SUPRA-MANDIBULAR BRANCH OF SEVENTH
INFRA-MANDIBULAR BRANCH OF SEVENTH
POSTERIOR AURICULAR
AURICULO-TEMPORAL
GREAT OCCIPITAL
FACIAL
LESSER OCCIPITAL
GREAT AURICULAR
SUPERFICIAL CERVICAL

(f) The **communicating twig to the pneumogastric** is given off at the same level as the chorda tympani, and joins the auricular branch of the pneumogastric while the latter is traversing the substance of the temporal bone.

(2) The branches which arise from the facial nerve between the stylo-mastoid foramen and the terminal bifurcation are the posterior auricular and the nerves to the posterior belly of the digastric and to the stylo-hyoid muscles. A lingual branch is also described.

(a) The **posterior auricular nerve** is the first branch of the extracranial portion of the facial. It passes between the parotid gland and the anterior border of the sterno-mastoid muscle, and runs upwards in the deep interval between the external auditory meatus and the mastoid process. In this situation it communicates with the auricular branch of the pneumogastric. It supplies the retrahens aurem, and sends a slender twig upwards to the attollens aurem, and ends in a long slender branch, which passes backwards to supply the posterior belly of the occipito-frontalis. It also receives filaments from the small occipital and posterior auricular nerves, and supplies the oblique and transverse muscles on the inner surface of the pinna.

(*b*) The **nerve to the posterior belly of the digastric** arises from the facial nerve close to the stylo-mastoid foramen, and enters the digastric near the centre of that muscle, or sometimes near its origin. It frequently communicates with the glosso-pharyngeal nerve.

(*c*) The **nerve to the stylo-hyoid** arises at the same level as the preceding nerve, the two nerves sometimes forming a common trunk. It ends in the upper part of the muscle for which it is destined.

The **lingual branch** is remarkable for its long course. It arises close to the two small muscular nerves above described. It passes on the outer side of the stylo-pharyngeus muscle, and gains the side of the pharynx. In this situation it is joined by filaments from the glosso-pharyngeal. It then passes between the palato-glossus muscle and the tonsil, and reaches the base of the tongue, where it ends in filaments to the mucous membrane and in twigs to the palato-glossus and stylo-glossus muscles. (Testut.)

(3) Six branches are given off from the two terminal divisions of the facial nerve. These branches traverse the substance of the parotid gland, and emerge at its margin. At their emergence they range from a point on the zygoma, a little in front of the spot where the temporal artery crosses the bone, to the angle of the lower jaw. These branches proceed forwards over the face and front of the neck, and by frequently communicating with one another form a great expanded plexus which is called the **pes anserinus.** Taken in order from above downwards, the temporo-facial division gives off the following branches: temporal, malar, and infraorbital. The cervico-facial division divides into buccal, supra-mandibular and infra-mandibular branches.

The **TEMPORO-FACIAL DIVISION** of the facial nerve runs obliquely upwards and forwards through the substance of the parotid gland, crosses the external carotid artery and the temporo-maxillary vein on the superficial aspect of those vessels, and terminates, as above described, in three branches.

In this course it receives communications from the auriculo-temporal nerve, as mentioned in the description of the fifth nerve.

(*a*) The **temporal branch** passes upwards through the parotid gland, and emerges at the upper border of the gland at a point a little in front of the temporal artery. It divides into several branches, which communicate with one another and with the malar branch. It also communicates with the temporal branch of the orbital, and with the supraorbital nerve. Its largest branches are distributed to the upper part of the orbicularis palpebrarum, and to the anterior belly of the occipito-frontalis. It also supplies the attrahens aurem, the corrugator supercilii, and, occasionally, the attollens aurem.

The fibres which run in the facial nerve to end in the orbicularis palpebrarum, the corrugator supercilii, and the frontalis muscles are probably derived from the oculo-motor nucleus of the same side, and pass downwards in the posterior longitudinal bundle to join the genu nervi facialis. (Mendel.)

(*b*) The **malar branch** is a smaller nerve than the preceding. It is directed upwards and forwards to reach the most prominent part of the malar bone; it supplies the lower part of the orbicularis palpebrarum. It also gives twigs to both eyelids; it communicates with the malar branch of the orbital, with the supraorbital and lachrymal branches of the ophthalmic, with the palpebral twigs derived from the superior maxillary division of the fifth, and with the temporal and infraorbital branches of the facial.

(*c*) The **infraorbital** is the largest of the nerves which enter into the pes anserinus. It escapes from the parotid gland above Stenson's duct, and divides into several branches. These branches communicate freely with one another, and pass inwards on the deep surface of the zygomatici and the levator labii superioris. Under cover of the latter muscle they communicate with the terminal branches of the superior maxillary division of the fifth nerve, forming the **infraorbital plexus**; thence twigs extend to the nose, and communicate with the nasal branch of the ophthalmic nerve. The infraorbital branch also forms communications with other branches of the facial, namely with the malar above and with the buccal below. It supplies the zygomatici, the levator labii superioris, the levator labii superioris alæque nasi, the levator anguli oris, the pyramidalis nasi, the compressor nasi, and the depressor alæ nasi. It also gives twigs to the buccinator and to the orbicularis oris.

The **CERVICO-FACIAL DIVISION** of the facial nerve is directed forwards and downwards through the parotid gland, and, like the temporo-facial division, it crosses on the outer side of the external carotid artery. As it traverses the glandular substance it communicates with the facial branches of the great auricular nerve. As above described, it terminates in three branches: the buccal, the supra-mandibular, and the infra-mandibular.

(*a*) The **buccal branch** is of small size, and is the highest of the three branches of the cervico-facial division. It is placed between the infraorbital and supra-mandibular branches of the facial, and communicates with both these branches. It emerges from the parotid gland below Stenson's duct, and crosses the masseter muscle. In front of the anterior border of the masseter, it communicates with the long buccal branch of the fifth, and then breaks into twigs, which end in the buccinator and orbicularis oris.

(*b*) The **supra-mandibular branch,** after escaping from the parotid gland, crosses the lower part of the masseter muscle, a little way above the angle of the lower jaw, and passes forwards, under cover of the risorius and the depressors of the lower lip, as far as the middle line. It communicates with the buccal and infra-mandibular branches of the facial, and with the mental branch of the mandibular nerve. It supplies the risorius, the depressor anguli oris, the depressor labii inferioris, and the levator menti.

(*c*) The **infra-mandibular branch** becomes superficial at the lower margin of the parotid gland, and runs obliquely downwards and forwards, under cover of the platysma, across the side and front of the neck. It forms one or more communicating loops, near its commencement, with the great auricular nerve, and longer loops, lower down, with the superficial cervical nerve. It supplies the platysma myoides.

EIGHTH OR AUDITORY NERVE

The **auditory nerve** appears at the lower border of the pons (superficial origin), immediately external to the facial nerve. It arises by two roots, a lateral and a mesial. These roots embrace the restiform body, the lateral root being external, and the mesial root internal to that body (fig. 450). The **lateral root** (superficial, dorsal, inferior, or posterior root) is continuous with the cochlear nerve, and is the true nerve of hearing; while the **mesial root** (deep, ventral, superior, or anterior root) is continued into the vestibular nerve, and is concerned in the maintenance of equilibrium. The nuclei in connection with these roots will be first described.

The **small-celled** or **chief nucleus** is superficially placed in the floor of the fourth ventricle. It is largest in the region of the striæ medullares, in which situation it appears in coronal sections as a triangular grey mass, which reaches the middle line. It extends forwards from this point as far as the abducens nucleus and backwards for about an equal distance. Both in front and behind it recedes from the middle line. The nerve-cells forming this nucleus are all of small size.

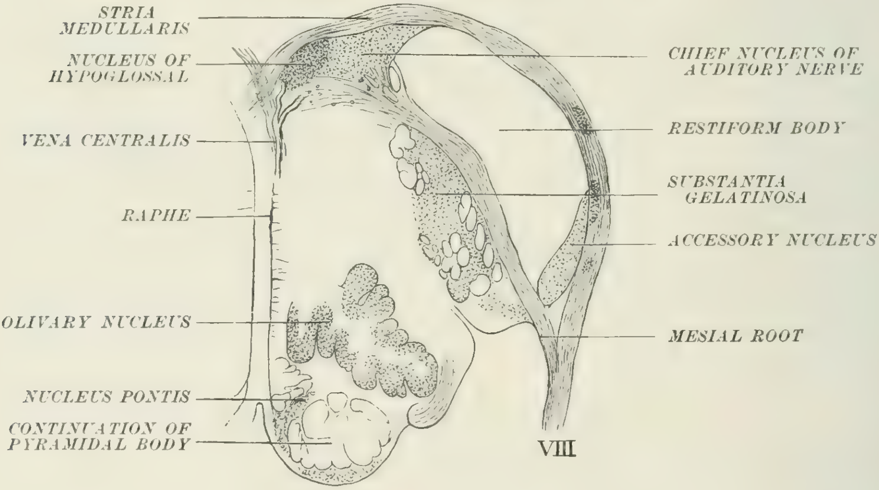
The **large-celled** or **Deiters' nucleus** is placed close to the inner side of the restiform body. It is about the same length as the small-celled nucleus, but occupies a position deeper and further forwards than the latter. The cells of this nucleus are of large size, and are most numerous at the anterior part. It degenerates after destruction of the upper cervical region of the cord or of the lateral lobe of the cerebellum of the same side, therefore it must have close associations with these parts, but it is probably unconnected with the auditory nerve.

The **accessory nucleus** (lateral or ventral nucleus) is a group of cells chiefly contained within the lateral root, but also occupying the angular interspace between the lateral and the mesial roots. It presents marked affinities to a spinal nerve-ganglion, particularly in the character of the nerve-cells in its anterior (superior) part. Some of the fibres which spring from it pass through the trapezium to the fillet of the opposite side, by means of which they reach the posterior quadrigeminate body, whilst others terminate in the upper olive of the same and the opposite sides.

Lateral root.—The lateral root arises chiefly from the cells of the accessory nucleus, but a certain number of fibres are believed to pass by that nucleus without interruption. Both sets of fibres travel in a tolerably compact bundle around the outer side of the restiform body. A certain number take origin in the cells of the tuberculum acusticum, the others cross the floor of the fourth ventricle, as striæ medullares, and, having crossed the middle line, take origin partly in the so-called nucleus funiculi teretis of the opposite side, and pass partly into the conductor sonorus. The origin of the **conductor sonorus** is unknown; its course has been noticed in the description of the fourth ventricle (page 719).

Mesial root.—This root passes to the inner side of the restiform body and has no connection with the ventral nucleus; most of its fibres terminate in the small-celled, chief, or dorsal nucleus, but some probably pass directly to the cerebellum.

FIG. 450.—TRANSVERSE SECTION OF THE PONS, PASSING THROUGH THE MOST DISTAL OF THE STRIÆ MEDULLARES. (Krause.)



There appears to be but little doubt that the superior temporal convolution is the cortical centre for hearing (Ferrier). According to Obersteiner, the probable links between the nerves of hearing and the cortical acoustic field are as follow: lateral root, accessory nucleus, superior olive, lateral fillet, posterior quadrigeminal body, internal geniculate body, temporal lobe.

The two roots unite at the ventral border of the restiform body, and the nerve thus formed, proceeding upwards, outwards, and forwards, enters the internal auditory meatus, near the outer end of which it divides into an anterior or upper, and a posterior or lower branch. In its course through the meatus, it is accompanied by the facial nerve, the pars intermedia, and the internal auditory artery. These structures are all contained in a common sheath of arachnoid. Within the meatus the auditory nerve becomes flattened, and it is curved in such a manner as to form a half-cylinder, open above. The pars intermedia lies in the concavity of this half-cylinder, and above this is the facial nerve, the three nerves being connected by a lax connective tissue. This connective tissue has often been mistaken for nervous communications. (Testut.)

The anterior or upper branch consists entirely of vestibular fibres, it divides into three parts which pass above the crista falciformis, through the area cribrosa superior, and are distributed to the utricle, and to the ampullæ of the superior and external semicircular canals. Ganglionic nerve-cells are found in this part of the nerve.

The lower or posterior branch contains both vestibular and cochlear fibres. It gives off the former in two twigs which contain ganglion cells, one passes through the area cribrosa media to the saccule, and the other through the foramen singulare to the ampulla of the posterior vertical semicircular canal. The remaining and larger part of the lower branch consists of cochlear fibres which pass through the tractus spiralis foraminulentus of the inferior cribriform area into the central canal of the modilus and the spiral lamina of the cochlea. They are connected with the nerve-cells of the spiral ganglion of the cochlea, and they terminate in the organ of Corti.

NINTH OR GLOSSO-PHARYNGEAL NERVE

The **glosso-pharyngeal nerve** is made up of fibres derived from three different sources. Two of these sets of fibres arise from distinct groups of cells, and represent the motor part of the nerve and the portion devoted to the special sense of taste. The third set of fibres takes the form of an ascending root (funiculus solitarius), the round cross-section of which forms a conspicuous object in sections through the lower part of the medulla. The fibres from these three sources emerge in the form of several fasciculi (superficial origin) in the groove between the olivary and restiform bodies, near the lower border of the pons, in series with the roots of the vagus nerve.

The two principal nuclei are called the small-celled and the large-celled nuclei, and are absolutely continuous with the nuclei of the vagus and of the accessory part of the spinal accessory nerve.

The **small-celled nucleus** (sensory, or accessorio-vago-glosso-pharyngeal nucleus) corresponds for the most part to the ala cinerea in the floor of the fourth ventricle. In this situation it lies immediately external to the chief nucleus of the hypo-glossal nerve. Higher up, it recedes from the middle line, and is more deeply placed, being covered by the chief nucleus of the auditory nerve. It is from this deeper (upper) part that the glosso-pharyngeal fibres take origin and these fibres are regarded as the conductors of the special sense of taste.

The **large-celled nucleus** (motor nucleus, nucleus ambiguus) contains cells resembling the motor cells in the anterior horn of the spinal cord, and is regarded as a portion of the head of that horn which has been amputated from the neck by the decussation of the pyramids. It is more deeply placed than the small-celled nucleus. It is placed between the nucleus lateralis and external accessory olive, and somewhat dorsally to both. It extends in a sagittal direction from the level of the striæ medullares downwards to a point a little below the fourth ventricle. From the upper end of this nucleus fibres pass dorsally and then arch outwards to join the fibres derived from the small-celled nucleus. Both sets of fibres then proceed forwards and outwards, piercing the ascending root of the trigeminal, and emerge at the ventral margin of the restiform body.

The **ascending root** (funiculus solitarius) commences at a point immediately above the level of the decussation of the pyramids. It passes upwards in the form of a sharply circumscribed round bundle, gaining in strength as it ascends. It is placed at first close to the outer side of the nucleus of the hypoglossal nerve; higher up it is related to the outer side of the small-celled (accessorio-vago-glosso-pharyngeal) nucleus (fig. 431), and lies dorsally to the roots of the vagus. Finally, at the level of the striæ medullares, it bends at right angles to its former course, and runs forwards and outwards, traversing the substantia gelatinosa and the ascending root of the trigeminal to join the rest of the glosso-pharyngeal nerve, forming the uppermost (most proximal) of the series of fasciculi which has been described as the superficial origin of that nerve.

The term ascending as applied to the fibres of the glosso-pharyngeal nerve which lie in the funiculus solitarius is unjustifiable. In reality the funiculus consists of fibres of the glosso-pharyngeal and vagus nerves, derived from the ganglion cells of these nerves, which are passing downwards to lower levels of the medulla, and which correspond, therefore, to a certain extent, with the fibres of the descending comma-shaped tract of the spinal cord.

From its superficial origin the glosso-pharyngeal nerve proceeds outwards and slightly forwards, below and in front of the flocculus, to reach the middle compartment of the jugular foramen, which it traverses in common with the vagus and spinal accessory nerves. As it passes through the foramen it is placed in front of, and a little internal to, the vagus and spinal accessory nerves, but occupies a separate compartment in the dura mater, and is lodged in a groove on the lower border of the petrous portion of the temporal bone. Having emerged at the base of the skull, it lies at first in contact with the vagus, but leaves the latter almost immediately and passes forwards and inwards between the internal jugular vein and the internal carotid artery and curves round the outer side of the latter vessel between it and the external carotid. In this part of its course it is placed under cover of the stylo-pharyngeus muscle. It then winds round the lower border of that muscle, and finally passes upwards in front of it and gains the deep surface of the hyoglossus, where it breaks up into its terminal or lingual branches. In the course above described, the glosso-pharyngeal describes a curve with the convexity directed downwards and backwards.

In its course through the jugular foramen, two ganglia are formed upon the trunk of the nerve, the lower of these bodies (petrous ganglion) is the more constant, the upper or jugular ganglion being generally regarded as a segmentation from the petrous ganglion. The two ganglia taken together are generally assumed to be equivalent to the ganglion on the posterior root of a spinal nerve.

The **jugular ganglion** (ganglion of Ehrenritter) is a small greyish body which involves only the back part of the nerve. It is lodged in the upper part of the groove in the temporal bone through which the nerve passes. This ganglion does not give off any branches.

The **petrous ganglion** (ganglion of Andersch) is an ovoid greyish body which probably involves all the fibres of the nerve. Its long axis coincides with the axis of the nerve, and measures two or three millimetres. It is placed in the lower part of the jugular fossa. The nerve of Jacobson and some communicating branches arise from it.

Branches.—The following branches are given off by the glosso-pharyngeal nerve:—(1) meningeal; (2) tympanic; (3) communicating; (4) muscular; (5) pharyngeal; (6) tonsillar; and (7) lingual.

(1) The **meningeal branches** are slender twigs which are given off within the cranium, and are distributed to the pia mater and arachnoid. (Bochdalek.)

(2) The **tympanic branch,** or nerve of Jacobson, is a small twig which arises from the petrous ganglion. It enters a minute canal (the tympanic canaliculus), which commences below on the ridge between the jugular fossa and the inferior opening of the carotid canal, and ends above, in the tympanic cavity, immediately below the promontory. The nerve, having traversed this canal, ramifies on the promontory, grooving the bone, and forming the tympanic plexus. The following branches arise from the nerve within the tympanum: (*a*) a **communicating twig** to the great superficial petrosal; (*b*) a **twig** to the lesser superficial petrosal, which is considered by some anatomists to be the main root of the nerve; (*c*) a **twig** to the mucous membrane surrounding the fenestra ovalis; (*d*) a **twig** to the fenestra rotunda; (*e*) a **twig** to the lining membrane of the Eustachian tube; (*f*) a **twig** which passes through the carotico-tympanic canal to join the carotid plexus of the sympathetic.

(3) The **communicating branches** arise from the petrous ganglion. One joins the superior cervical ganglion of the sympathetic; another forms a loop with the auricular branch of the vagus; while a third, less constant than the other two, joins the ganglion of the root of the vagus. Immediately below the petrous ganglion a twig is given off which joins the lingual branch of the facial as above described (page 764).

(4) The **muscular branch** is distributed to the stylo-pharyngeus muscle. This branch receives a communication from the facial.

According to Testut, the glosso-pharyngeal gives off carotid branches which join the carotid plexus of the sympathetic and also muscular twigs to the digastric, stylo-hyoid, and stylo-glossus muscles.

(5) The **pharyngeal branches** may be two or three in number, and arise from the nerve a short distance below the petrous ganglion. The principal and most constant of these nerves passes on the outer side of the internal carotid artery, and after a very short independent course joins the pharyngeal branch of the vagus to form the pharyngeal plexus with that nerve, and with branches of the superior cervical ganglion.

(6) The **tonsillar branches** are a number of small twigs which arise under cover of the hyo-glossus muscle; these proceed to the tonsil, around which they form a plexus. From this plexus fine twigs proceed to the pillars of the fauces and to the soft palate.

(7) The **lingual branches** arise from the termination of the nerve and proceed to the dorsum of the tongue, where they are chiefly distributed to the circumvallate papillæ. Some small twigs pass backwards to the follicular glands of the tongue, and to the anterior surface of its epiglottis. Other twigs are distributed around the foramen cæcum, where they communicate with the corresponding twigs of the opposite side.

TENTH OR PNEUMOGASTRIC NERVE

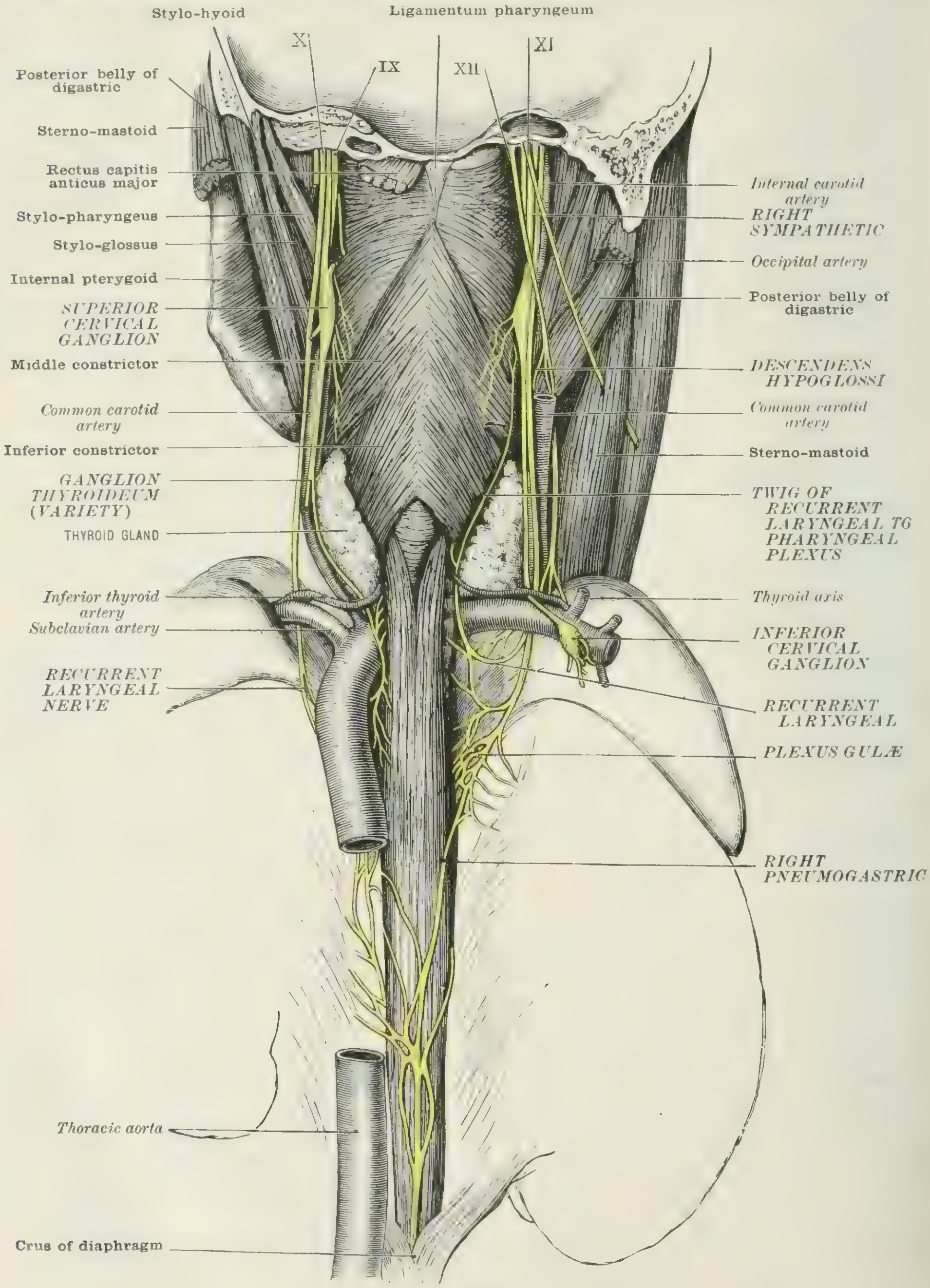
The **pneumogastric** or **vagus nerve** is the longest of the cranial nerves. It is remarkable for its extensive distribution, for the asymmetry which it shows in certain parts of its course and distribution, and for the almost vertical course which it pursues. It supplies, as its name implies, the lungs and the stomach, but also furnishes branches to the external ear, the pharynx, larynx, œsophagus, trachea, heart, and abdominal viscera.

The pneumogastric nerve arises in the medulla in a manner nearly identical with the glosso-pharyngeal nerve, the roots of the former nerve being a serial continuation of the roots of the latter. Thus we find that sensory roots arise from the small-celled nucleus (in a position corresponding to the ala cinerea in the floor of the fourth ventricle), and motor roots arise from the nucleus ambiguus. The latter arch round to join the sensory roots. The vagus is also said to be connected by a few fine filaments with the funiculus solitarius. The roots from these different sources unite and pass forwards and outwards to emerge (superficial origin) in the form of from ten to fifteen fasciculi, between the restiform body and the lateral column of the medulla. This row of fasciculi is in series above with the glosso-pharyngeal roots, and below with the bulbar roots of the spinal accessory. The roots of these three nerves cannot be distinguished from one another either at their superficial origin, or at the points where they spring from their nuclei in the medulla, unless the connection of the roots with their respective trunks has been preserved.

From its superficial origin the vagus nerve proceeds outwards and slightly upwards and forwards beneath the flocculus to reach the jugular foramen. It traverses the middle compartment of the foramen accompanied by the spinal accessory and glosso-pharyngeal nerves. The former nerve occupies the same compartment in the dura mater as the vagus. The glosso-pharyngeal is provided with a separate sheath, and is in front of and somewhat internal to the other two nerves. As the vagus traverses the jugular foramen it bends at a right angle to its former course, and proceeds vertically downwards. In its course down the neck it is placed in front of the rectus capitis anticus major and longus colli muscles, but separated from them by the prevertebral layer of the cervical fascia. In the upper part of the neck it is placed between and on a plane posterior to the internal jugular vein and the internal carotid artery. In the lower part of the neck it occupies a similar position in regard to the internal jugular vein and common carotid artery, the vein being in front and external, and the artery in front and internal to the nerve. The three structures are enclosed in a common sheath derived from the deep cervical fascia.

In their course through the thorax the nerves of the left and right sides differ in some respects from each other.

Fig. 451.—Distribution of the Pneumogastric Nerve, viewed from behind. (Krause.)


Stylo-hyoid
Ligamentum pharyngeum
X
IX
XII
XI
Posterior belly of digastric
Sterno-mastoid
Rectus capitis anticus major
Stylo-pharyngeus
Stylo-glossus
Internal pterygoid
SUPERIOR CERVICAL GANGLION
Middle constrictor
Common carotid artery
Inferior constrictor
GANGLION THYROIDEUM (VARIETY)
THYROID GLAND
Inferior thyroid artery
Subclavian artery
RECURRENT LARYNGEAL NERVE
Internal carotid artery
RIGHT SYMPATHETIC
Occipital artery
Posterior belly of digastric
DESCENDENS HYPOGLOSSI
Common carotid artery
Sterno-mastoid
TWIG OF RECURRENT LARYNGEAL TO PHARYNGEAL PLEXUS
Thyroid axis
INFERIOR CERVICAL GANGLION
RECURRENT LARYNGEAL
PLEXUS GULÆ
RIGHT PNEUMOGASTRIC
Thoracic aorta
Crus of diaphragm

The **right vagus nerve** passes in front of the first stage of the subclavian artery between the latter and the right innominate vein, and then, inclining backwards, runs downwards on the side of the trachea, posterior to the right innominate vein and the superior vena cava, to reach the posterior aspect of the right bronchus. Behind the bronchus it expands into a great, flat, plexiform band, from which the posterior pulmonary plexus proceeds. The vagus then inclines inwards in the form of two cords, and communicates with the pneumogastric of the opposite side both in front and behind the œsophagus to form the œsophageal plexus (plexus gulæ). Having interchanged a considerable number of fibres with the other nerve, the right vagus then descends (having regained the form of one nerve) behind the œsophagus through the œsophageal opening of the diaphragm, and spreads out on the posterior surface of the stomach.

The **left vagus nerve** enters the thorax behind the left common carotid artery between the latter and the left subclavian artery. As it approaches the arch of the aorta it bends suddenly backwards, and crosses the root of the subclavian artery on the left side of that vessel, immediately under cover of the pleura. It then crosses the left side (in front) of the arch of the aorta, and bends backwards to reach the posterior aspect of the left bronchus, where it spreads out in a similar manner to the nerve of the right side. It then descends on the œsophagus, entering into the plexus gulæ, and on reaching the diaphragm passes in the form of a single trunk in front of the œsophagus into the abdominal cavity, and spreads out on the anterior surface of the stomach.

At the base of the skull the vagus presents two ganglia: an upper ganglion, or ganglion of the root; and a lower, or ganglion of the trunk.

The **ganglion of the root** is placed within the jugular foramen opposite the jugular ganglion of the glosso-pharyngeal. It is an irregular greyish swelling of from four to six millimetres in length. It is usually regarded as corresponding to a spinal ganglion.

The **ganglion of the trunk,** situated a little below the preceding, is a fusiform enlargement of the nerve about twenty millimetres in length, and four to five millimetres in transverse diameter at its thickest part. The hypoglossal nerve is firmly attached to it by connective tissue and encloses it in a spiral turn, being placed at first to the inner side of the vagus, then passing behind, then to its outer side, and finally crossing it in front. The superior cervical ganglion of the sympathetic is behind and a little external to the vagus; the glosso-pharyngeal is in front of it. The accessory portion of the spinal accessory nerve joins the ganglion of the trunk; some of the fibres running over the ganglion into the pharyngeal and superior laryngeal branches.

Branches.—The branches of the vagus may be classified into (1) communicating branches; and (2) branches of distribution.

(1) **Communicating branches.**—The vagus communicates with the following nerves:—(*a*) the glosso-pharyngeal to the auricular branch of the pneumogastric; (*b*) the spinal accessory; (*c*) the hypoglossal; (*d*) the sympathetic; and (*e*) the upper two spinal nerves.

(*a*) Besides the communicating branch to the vagus just referred to, a communicating twig is given off from the pneumogastric, close to the base of the skull, which joins the glosso-pharyngeal nerve immediately below the petrous ganglion.

(*b*) The **spinal accessory** gives some fine filaments to the ganglion of the root of the vagus within the jugular foramen. Lower down, the remainder of the accessory portion joins the ganglion of the trunk.

(*c*) The **hypoglossal** furnishes two or three fine filaments to the ganglion of the trunk of the vagus. These filaments are given off by the hypoglossal as it winds round the ganglion.

(*d*) Two or three **twigs** from the **superior cervical ganglion of the sympathetic** join the ganglia of the trunk and root. Lower down the branches of distribution of the vagus communicate extensively with the sympathetic.

(*e*) A **twig** passes from the loop formed by the anterior primary divisions of the upper two spinal nerves to the ganglion of the trunk of the vagus. This communication is not constant.

(2) **Branches of distribution.**—These are (*a*) the meningeal; (*b*) auricular; (*c*) pharyngeal; (*d*) superior laryngeal; (*e*) inferior laryngeal; (*f*) cardiac; (*g*) pulmonary; (*h*) œsophageal; and (*i*) abdominal branches.

(*a*) The **meningeal** or **recurrent branch** is a slender filament which is given off from the ganglion of the root. It takes a recurrent course through the jugular foramen, and is distributed to the dura mater around the lateral sinus.

(*b*) The **auricular branch,** or **nerve of Arnold,** arises from the ganglion of the root in the jugular foramen. It traverses the bone, passing to the inner side of the aqueduct of Fallopius; forming a communication with the facial nerve, and emerges behind the pinna, where it divides into two branches, one of which joins the posterior auricular branch of the facial while the other supplies the posterior and inferior part of the external auditory meatus and the back of the pinna. It also supplies twigs to the osseous part of the external auditory meatus and to the lower part of the outer surface of the membrana tympani.

(*c*) The **pharyngeal branches** may be two or three in number. The principal of these joins the pharyngeal branch of the glosso-pharyngeal in front of the internal carotid artery, and passes with the latter behind the external carotid artery downwards and inwards to reach the posterior aspect of the pharynx. Here the two nerves are joined by branches from the superior cervical ganglion of the sympathetic, and form, with the latter, the pharyngeal plexus.

(*d*) The **superior laryngeal nerve** arises from the lower part of the ganglion of the trunk, and passes obliquely downwards and inwards behind and internal to both internal and external carotid arteries towards the larynx. In this course it describes a curve with the convexity downwards and outwards, and divides into (i) a larger internal and (ii) a smaller external branch. Before its division it is joined by communications from the sympathetic and from the pharyngeal plexus.

(i) The **internal branch** accompanies the superior laryngeal artery to the interval between the upper border of the thyroid cartilage and the great cornu of the hyoid bone. It passes under cover of the thyro-hyoid muscle and pierces the thyro-hyoid membrane to gain the interior of the larynx; here it divides into a number of diverging branches. The ascending branches supply the mucous membrane on both surfaces of the epiglottis. The descending branches ramify in the mucous membrane lining the larynx, communicate with the recurrent laryngeal nerve, and supply the mucous membrane which covers the back of the cricoid cartilage.

(ii) The **external laryngeal branch** runs downwards towards the lower border of the thyroid cartilage. It pierces the lower fibres of the inferior constrictor of the pharynx, and ends for the most part in the crico-thyroid muscle. A few filaments pierce the crico-thyroid membrane, and are distributed to the lining membrane of the larynx. It gives off a cardiac branch which joins one of the cardiac branches of the sympathetic; it also furnishes twigs to the inferior constrictor and communicating twigs to the pharyngeal plexus, and it receives a communication from the superior cervical ganglion of the sympathetic.

(*e*) The **inferior** or **recurrent laryngeal nerve of the right side** arises at the root of the neck in front of the first stage of the right subclavian artery. It hooks round the artery, passing below and then behind that vessel, and runs upwards and slightly inwards, crossing obliquely behind the common carotid artery. Having gained the side of the trachea, it runs upwards in the groove between that canal and the œsophagus, accompanied by the inferior thyroid artery, and enters the larynx by passing under cover of the lower border of the inferior constrictor of the pharynx. It then breaks up into branches, which are distributed to all the intrinsic muscles of the larynx with the exception of the crico-thyroid, and it communicates, as above mentioned, with the superior laryngeal nerve. Near its commencement it usually gives off a cardiac branch.

In its course between the œsophagus and trachea it gives numerous twigs to these structures, and near the termination it furnishes one or two twigs to the inferior constrictor of the pharynx.

On the **left side** the nerve arises in front of the aortic arch, and winds round the concavity of the arch just behind the obliterated ductus arteriosus. It crosses obliquely behind the root of the left common carotid artery, gains the angular interval between the œsophagus and trachea, and corresponds to the nerve of the right side for the remainder of its course and distribution.

(*f*) **Cardiac branches.**—These are named (from the different levels at which they take origin) cervical and thoracic, and form altogether three or four pairs of nerves. These all proceed to the deep cardiac plexus, with one exception, the inferior cervical cardiac of the left side, which joins the superficial cardiac plexus.

(i) The **superior cervical cardiac nerves**, one or two in number, join the corresponding branches from the sympathetic. A full account of these nerves will be given in the description of the cardiac plexus. (See SYMPATHETIC SYSTEM.)

(ii) The **inferior cervical cardiac nerve of the left side** passes downwards on the left side of the aortic arch between the latter and the pleura, and joins the superficial cardiac plexus. As it crosses the arch the phrenic nerve is in front of it, and the left upper cervical cardiac of the sympathetic is behind it. The **right** inferior cervical cardiac passes downwards on the side of the trachea to join the deep cardiac plexus.

(iii) The **thoracic cardiac branches** usually arise close to and in connection with the recurrent laryngeal nerves; consequently the nerves on the left side arise a little lower than the right. They are directed inwards to the front of the lower end of the trachea to terminate in the deep cardiac plexus.

(*g*) The **anterior pulmonary branches** are one or two small twigs, which arise at the upper border of the root of the lung and pass forwards to gain the anterior aspect of the bronchus, where they communicate with the sympathetic and form the anterior pulmonary plexus, whence fine twigs pass along the bronchus into the lung.

The **posterior pulmonary plexus** is formed by a great flattened expansion of the pneumogastric nerve on the posterior aspect of the bronchus. From this several stout twigs proceed, which communicate with twigs from the second, third, and fourth thoracic ganglia of the sympathetic, and pass into the lung, and it anastomoses with the corresponding plexus of the opposite side.

(*h*) **Œsophageal branches.**—Numerous twigs are given off from the plexus gulæ as it encircles the œsophagus, and are distributed to the muscular and mucous coats of that canal.

(*i*) **Abdominal branches.**—The termination of the **left** vagus nerve passes through the œsophageal opening in the diaphragm on the anterior aspect of the œsophagus, and is distributed over the anterior surface of the stomach. The strongest branches accompany the coronary artery along the lesser curvature of the stomach, and, from these, twigs pass on to the hepatic artery and join the hepatic plexus. The termination of the **right** vagus is distributed upon the posterior surface of the stomach, and gives twigs to the cœliac, splenic, and left renal plexuses.

ELEVENTH OR SPINAL ACCESSORY NERVE

The **spinal accessory nerve** consists of two distinct parts, which are usually known as the spinal and the accessory portions of the nerve. The former of these (spinal portion) is a purely motor nerve which arises from the nerve-cells in the ventro-lateral group of the anterior cornu of the cervical portion of the spinal cord. The accessory portion, on the other hand, arises by a series of roots from the distal parts of both the motor and sensory accessorio-vago-glosso-pharyngeal nuclei in the medulla, and would be more properly described as the most distal vagal roots (Obersteiner) than as a separate nerve.

The **accessory portion** (distal vagal roots, or bulbar accessory) consists of four or five fasciculi which arise in a precisely similar manner to the roots of the vagus with which they are in series. Shortly after their emergence from the medulla they join the spinal portion and accompany the latter through the jugular foramen. Having gained the exterior of the skull, the bulbar accessory leaves the nerve with which it has been associated in part of its course, and joins the ganglion of the root of the vagus; some of its fibres pass into the pharyngeal and superior laryngeal nerves as already described.

The **spinal portion** arises from the ventro-lateral group of nerve-cells in the anterior cornu of the cervical portion of the spinal cord. Some of the fibres run longitudinally for a short distance and join other more direct fibres, which arch backwards and outwards to emerge from the lateral column of the cord between the posterior nerve roots and the attachment of the ligamentum denticulatum. The superficial origin of the nerve is thus constituted by a row of filaments which extend from the fifth or sixth (rarely the seventh) to the first cervical nerve. The lowest of this series of roots is close to the ligamentum denticulatum; the highest is near to the point of emergence of the posterior roots of the first cervical nerve. The roots unite to form a rounded cord which courses upwards, increasing in size as it ascends, and enters the cranial cavity by passing through the foramen magnum. Here it is joined, for the time being, by the accessory portion, and passes with the latter, in the form of a single trunk, through the middle compartment of the jugular foramen. At the base of the skull it runs downwards, outwards, and backwards between the occipital artery and the internal jugular vein, to pass under cover of the sterno-mastoid muscle; it pierces the clavicular fibres of the muscle and communicates with a branch derived from the second cervical nerve. From the plexus so formed the sterno-mastoid is supplied. The nerve then emerges at the posterior border of the muscle, crosses the floor of the posterior triangle of the neck obliquely, and passes under cover of the trapezius; on the deep surface of that muscle the spinal accessory is joined by branches from the third and fourth cervical nerves, and forms with them the subtrapezial plexus, from which the trapezius is supplied.

TWELFTH OR HYPOGLOSSAL NERVE

The **hypoglossal nerve** arises from an elongated column of nerve-cells which extends from the striæ medullares in the floor of the fourth ventricle downwards to the level of the lower end of the olivary body. This column contains nerve-cells of large size. It represents the neck of the anterior horn of the grey crescent in the spinal cord, and is continued into that structure below. In its lower part the column is placed ventro-laterally to the central canal, but, as the central canal expands into the floor of the fourth ventricle, the grey column is displaced laterally, and thus apparently occupies a more dorsal position. It corresponds to the area described as the trigonum hypoglossi, and is separated from the ependyma of the ventricle only by a thin layer of medullated fibres. From the cells embedded in this grey column the nerve-fibres arise. These fibres pass in bundles which are directed ventrally and outwards, internal to the olivary nucleus, between the latter and the internal accessory olive. Finally they emerge in a row of from ten to twelve filaments in the furrow between the olivary and pyramidal bodies, constituting the superficial origin of the hypoglossal nerve.

An accessory nucleus is also described which is placed ventro-laterally to the above described (or chief) nucleus. This accessory nucleus represents a portion of the head of the anterior horn.

Fibres pass from the inner side of the hypoglossal nucleus, and cross in the raphe from where they ascend brainwards to establish the cortical origin of the nerve.

The filaments unite to form two fasciculi, each of which pierces the dura mater separately at a point opposite to the anterior condyloid foramen. As these fasciculi traverse the foramen, they unite to form a single trunk, which is placed at first on the inner side of the pneumogastric, but then winds spirally round the ganglion of the trunk of the latter nerve, passing behind, external to, and finally in front of the ganglion. In this situation the hypoglossal receives two or three communicating branches from the first and second cervical nerves, and some minute twigs from the vagus and sympathetic. The hypoglossal then runs forwards and inwards, describing a curve, the convexity of which looks downwards and outwards. At the commencement of this part of its course it crosses the internal carotid artery and hooks round the occipital artery, passing immediately below that vessel. It then crosses external to the external carotid artery, the lingual artery, the middle constrictor of the pharynx, and the hyo-glossus muscle, and, passing under cover of the mylo-hyoid, breaks up into its terminal branches. As it lies on the middle constrictor the great cornu of the hyoid bone is below it and the tendon of the digastric muscle is above it. As it passes on to the hyo-glossus it is crossed on its superficial surface by the digastric and stylo-hyoid muscles. It is also overlapped in this situation by the submaxillary gland.

Branches.—The **meningeal branch** (Luschka) is given off by the hypoglossal as it is traversing the anterior condyloid foramen, and takes a recurrent course into the cranial cavity, where it is distributed to the dura mater. It is probably derived from the communicating branches of the pneumogastric or from the first cervical nerve.

The remaining branches of the hypoglossal may be classified into branches of the cervical plexus which are simply adherent for the time being to the cranial nerve, and true hypoglossal branches; the latter are exclusively distributed to the muscles of the tongue and the genio-hyoid.

The **BRANCHES DERIVED FROM THE CERVICAL PLEXUS** are the descendens hypoglossi, and the muscular twig to the thyro-hyoid muscle.

The **descendens hypoglossi** parts company with the hypoglossal at the point where the latter hooks round the occipital artery. It runs downwards and slightly inwards on the sheath of the great vessels (occasionally within the sheath), and is joined at a variable level by the communicantes hypoglossi from the second and third cervical nerves, forming a loop, the ansa hypoglossi. The **ansa hypoglossi** may be placed at any level from a point immediately below the occipital artery to about an inch and a half above the sternum. A twig to the anterior belly of the omo-hyoid arises from the descendens hypoglossi in the upper part of its course. The nerves which supply the sterno-hyoid, sterno-thyroid, and posterior belly of the omo-hyoid are given off by the ansa hypoglossi. Twigs from the first two nerves pass in the muscles behind the manubrium sterni and in rare cases communicate with the phrenic within the thorax. The nerve to the posterior belly of the omo-hyoid runs in a loop of the cervical fascia below the central tendon of the muscle.

The **nerve to the thyro-hyoid** is given off near the tip of the great cornu of the hyoid bone, and runs obliquely downwards and inwards to reach the muscle.

The **TRUE HYPOGLOSSAL BRANCHES** supply the stylo-glossus, hyo-glossus, genio-hyo-glossus, the genio-hyoid, and the intrinsic muscular fibres of the tongue.

The **nerve to the stylo-glossus** is given off near the outer border of the hyo-glossus. It pierces the stylo-glossus, and its fibres pursue a more or less recurrent course within the muscle.

The **nerves to the hyo-glossus** are several twigs which are supplied to the muscle as the hypoglossal nerve crosses it.

The **nerves to the genio-hyo-glossus** and **genio-hyoid** arise under cover of the mylo-hyoid in common with the terminal branches to the intrinsic muscles of the tongue. They communicate freely with branches of the lingual, forming long loops which lie on the hyo-glossus muscle. From these loops twigs pass into the genio-hyo-glossus and into the muscular substance of the tongue.

SPINAL NERVES

The **spinal nerves** spring from the spinal cord by four long series of roots, namely, an anterior and a posterior series on each side of the cord. These origins correspond with the superficial origins of the cranial nerves, being the points at which the nerve-fibres emerge from the cerebro-spinal axis. Like the cranial nerves, the spinal nerves have also a deep origin. This is situated in the anterior and posterior horns of the grey crescents and has been already described (page 738). The spinal nerves also resemble the cranial nerves, inasmuch as this 'deep' origin is only a preliminary interruption in nerve-cells or in plexuses in the grey matter, and from the deep origin tracts of fibres pass upwards to establish a connection with the cerebral cortex. They differ from the cranial nerves inasmuch as they arise from the spinal cord instead of from the encephalon, in their mode of origin by an anterior motor and posterior sensory root, and by the development, on each of the posterior roots, of a ganglion (the spinal ganglion). Certain of the cranial nerves resemble the spinal nerves in the two latter respects; for example, the vagus arises from the large-celled (motor nucleus), a derivative of the anterior horn, and from the small-celled (sensory nucleus) derived from the basal part of the posterior horn; the roots from these two sources have, however, united before the nerve has reached the surface of the medulla. The ganglion of the root of the vagus and the ganglion on the sensory root of the trigeminal (Gasserian ganglion) are clearly homologous to the ganglia on the posterior roots of the spinal nerves. The hypoglossal nerve is, in rare cases, joined by a small posterior root on which a ganglion is developed, and, on the other hand, cases are recorded in which the posterior root of the first spinal nerve was devoid of a ganglion.

The **anterior roots** stand out in marked contrast to the posterior roots in regard to their function, being motor, whereas the posterior roots are sensory. They also differ from the posterior roots in several anatomical points. The anterior roots (with the single exception of the first) are smaller than the posterior; they arise by four to six fasciculi, and their origins do not form a linear series, but map out a longitudinal area of one to two millimetres in breadth on the surface of the cord. The posterior roots are larger than the anterior, they arise by six to eight fasciculi, are placed in a strictly linear series, and, as each root is traversing the corresponding intervertebral foramen, it enters into a spinal ganglion, a structure with which the motor root has no connection whatever.

The **posterior roots** are from one and a half to three times as large as the anterior, the ratio being—

1 to 1·5 in the thoracic nerves.
1 to 2 in the lumbar nerves.
1 to 3 in the cervical nerves.

Course and direction.—From their superficial origin, both anterior and posterior roots proceed towards the intervertebral foramina, and unite near the outer limits of the foramina into single trunks. The ganglia on the posterior roots are placed, in the case of the majority of the nerves, within the foramina immediately internal to the point of junction of the two roots. The ganglia of the first and second cervical nerves are placed on the laminæ of the atlas and axis. The ganglia of the sacral and coccygeal nerves are placed within the spinal canal. Each spinal ganglion is an ovoid greyish body, the long axis of which corresponds to the axis of the nerve with which it is incorporated. It is somewhat adherent to its meningeal sheath.

The roots of the first spinal nerve ascend slightly to reach the interval between the atlas and the occipital bone. The second and third nerves pass horizontally outwards, the fourth passes obliquely downwards and outwards, and the remaining nerves pass out with increasing degrees of obliquity, the intraspinal course of the nerve-roots increasing in length as the series is followed downwards. It follows from the above statement that the lower nerve-roots are directed almost vertically downwards, and as the spinal cord ends at the level of the second lumbar vertebra, while the series of intervertebral foramina is continued to the lower end of the sacrum, the nerve-roots passing within the vertebral canal beyond the cord form a great sheaf of fibres, the **cauda equina** (fig. 437). The distance of the points of emergence (superficial origins) of certain of the nerves from the corresponding intervertebral foramina is given in the following table. This table gives the measurements made by Testut in a subject of eighteen years. The length of the spinal cord was in this case forty-one centimetres.

	Right side mm.	*Left side* mm.
Third pair of cervical nerves	18	17
Fifth ,, ,, ,,	25	25
First ,, thoracic ,,	33	32
Fifth ,, ,, ,,	47	47
Tenth ,, ,, ,,	68	68
Twelfth ,, ,, ,,	111	110
First ,, lumbar ,,	114	114
Second ,, ,, ,,	138	134
Third ,, ,, ,,	151	151
Fourth ,, ,, ,,	163	164
Fifth ,, ,, ,,	181	180
First ,, sacral ,,	188	188
Fifth ,, ,, ,,	280	280

Each spinal nerve, as it enters the intervertebral foramen, is enclosed in a strong tubular sheath formed by the dura mater. This sheath is at first divided by a partition into two compartments, one for the anterior and the other for the posterior root. The septum soon disappears and allows the posterior and anterior roots to intermingle their fibres. Immediately beyond the ganglion on the posterior root the sheath thins away into the epineurium and perineurium of the nerve. The arachnoid and pia mater also send tubular processes around the nerves; these become continuous with the perineurium, and a connection is thus established between the lymph spaces around the nerves and the subdural and subarachnoid spaces.

Topography.—The relation of the superficial origins of the spinal nerves to the spinous processes of the vertebræ has been investigated by Nuhn, and more recently by Reid. In the following table, which is given by the latter anatomist, A signifies the highest point of origin; B the lowest point of origin; it gives the extreme limits of origin as observed in six subjects. For example, the origin of the sixth thoracic nerve *may* extend as high as the lower border of the spine of the second thoracic vertebra, or as low as the upper border of the spine of the fifth, but it does not necessarily extend either as high or as low as the points indicated.

Nerves	
Second cervical	(A) A little above the posterior arch of atlas. (B) Midway between posterior arch of atlas and spine of axis.
Third ,,	(A) A little below posterior arch of atlas. (B) Junction of upper two-thirds and lower third of spine of axis.
Fourth ,,	(A) Just below upper border of spine of axis. (B) Middle of spine of third cervical vertebra.
Fifth ,,	(A) Just below lower border of spine of axis. (B) Just below lower border of spine of fourth cervical vertebra.
Sixth ,,	(A) Lower border of spine of third cervical vertebra. (B) Lower border of spine of fifth cervical vertebra.
Seventh ,,	(A) Just below upper border of spine of fourth cervical vertebra. (B) Just above lower border of spine of sixth cervical vertebra.
Eighth ,,	(A) Upper border of spine of fifth cervical vertebra. (B) Upper border of spine of seventh cervical vertebra.
First thoracic	(A) Midway between spines of fifth cervical and sixth cervical vertebræ. (B) Junction of upper two-thirds and lower third of interval between seventh cervical and first thoracic vertebræ.
Second ,,	(A) Lower border of spine of sixth cervical vertebra. (B) Just above lower border of spine of first thoracic vertebra.
Third ,,	(A) Just above middle of spine of seventh cervical vertebra. (B) Lower border of spine of second thoracic vertebra.

Nerves		
Fourth thoracic	(A)	Just below upper border of spine of first thoracic vertebra.
	(B)	Junction of upper third and lower two-thirds of spine of third thoracic vertebra.
Fifth ,,	(A)	Upper border of spine of second thoracic vertebra.
	(B)	Junction of upper quarter and lower three-quarters of spine of fourth thoracic vertebra.
Sixth ,,	(A)	Lower border of spine of second thoracic vertebra.
	(B)	Just below upper border of spine of fifth thoracic vertebra.
Seventh ,,	(A)	Junction of upper third and lower two-thirds of spine of fourth thoracic vertebra.
	(B)	Just above lower border of spine of fifth thoracic vertebra.
Eighth ,,	(A)	Junction of upper two-thirds and lower third of interval between spines of fourth thoracic and fifth thoracic vertebræ.
	(B)	Junction of upper quarter and lower three-quarters of spine of sixth thoracic vertebra.
Ninth ,,	(A)	Midway between spines of fifth thoracic and sixth thoracic vertebra.
	(B)	Upper border of spine of seventh thoracic vertebra.
Tenth ,,	(A)	Midway between spines of sixth thoracic and seventh thoracic vertebræ.
	(B)	Middle of spine of eighth thoracic vertebra.
Eleventh ,,	(A)	Junction of upper quarter and lower three-quarters of spine of seventh thoracic vertebra.
	(B)	Just above spine of ninth thoracic vertebra.
Twelfth ,,	(A)	Junction of upper quarter and lower three-quarters of spine of eighth thoracic vertebra.
	(B)	Just below spine of ninth thoracic vertebra.
First lumbar	(A)	Midway between spines of eighth thoracic and ninth thoracic vertebræ.
	(B)	Lower border of spine of tenth thoracic vertebra.
Second ,,	(A)	Middle of spine of ninth thoracic vertebra.
	(B)	Junction of upper third and lower two-thirds of spine of eleventh thoracic vertebra.
Third ,,	(A)	Middle of spine of tenth thoracic vertebra.
	(B)	Just below spine of eleventh thoracic vertebra.
Fourth ,,	(A)	Just below spine of tenth thoracic vertebra.
	(B)	Junction of upper quarter and lower three-quarters of spine of twelfth thoracic vertebra.
Fifth ,,	(A)	Junction of upper third and lower two-thirds of spine of eleventh thoracic vertebra.
	(B)	Middle of spine of twelfth thoracic vertebra.
First sacral	(A)	Just above lower border of spine of eleventh thoracic vertebra.
Fifth ,,	(B)	Lower border of spine of first lumbar vertebra.
Coccygeal	(A)	Lower border of spine of first lumbar vertebra.
	(B)	Just below upper border of spine of second lumbar vertebra.

Classification and number.—There are thirty-one pairs of spinal nerves, viz.—eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal nerve. The cervical nerves are named from the vertebræ below them; the thoracic, lumbar, sacral and coccygeal nerves from the vertebræ above them. The first cervical or suboccipital nerve escapes through the interval between the occipital bone and the atlas; the eighth cervical passes through the intervertebral foramen between the seventh cervical and first thoracic vertebræ.

General distribution.—Each spinal nerve, at its exit from the intervertebral foramen, gives a small **recurrent branch** (Luschka), which receives a communicating twig from the sympathetic, and re-enters the neural canal to be distributed to the meninges and blood-vessels within the canal. Immediately after its exit each nerve divides into an anterior and a posterior primary division. Both the anterior and posterior primary divisions are mixed nerves, containing fibres derived from both the anterior and the posterior roots.

The **posterior primary divisions** are, with two exceptions, smaller than the anterior divisions. The posterior divisions of the first and second cervical nerves are larger than the anterior; that of the second cervical nerve being three or four times as large as the anterior division. In the regions of the great plexuses (brachial, lumbar, and sacral) the anterior division is very much larger than the posterior, particularly in the case of the upper sacral nerves. The posterior primary divisions are distributed to the integument of the occiput, posterior aspect of the neck, of the back, and of the greater part of the gluteal region. They also supply the muscles of the posterior part of the neck and the muscles of the back, with the exception of such of the posterior cervical and dorsal muscles as are connected with the superior extremity, the serrati postici, and the levatores costarum.

The **anterior primary divisions** may be broadly stated to supply the anterior surface of the body from the level of the chin downwards, and also the limbs. Each anterior division is connected with the sympathetic system by **rami communicantes.** The anterior divisions contrast forcibly with the posterior divisions in the great size that they attain to in the lower cervical and lumbo-sacral regions. In these regions they communicate with one another to form plexuses, from which a number of branches are given off to supply the limbs.

POSTERIOR PRIMARY DIVISIONS

The **posterior primary divisions of the spinal nerves** are, with the exception of the first and second cervical nerves, smaller than the anterior divisions. With the exception of the first cervical, the fourth and fifth sacral and the coccygeal nerves, each nerve divides shortly after its commencement into an internal and an external branch.

CERVICAL NERVES.—The posterior divisions of the first and second cervical require separate description. The third, fourth, and fifth cervical nerves are of small size. They pass backwards at the outer border of the semispinalis colli, and divide into internal and external branches.

The **internal branches** pass between the semispinalis colli and the complexus, giving twigs to both these muscles and to the multifidus spinæ. They then pass between the complexus muscle and the ligamentum nuchæ, pierce the origin of the trapezius, and are distributed to the integument of the back of the neck. As they enter the fasciæ they are directed upwards and outwards. The branch from the third nerve is directed nearly vertically upwards, and is called the third or **smallest occipital nerve.** It communicates with the great occipital nerve and reaches the integument of the occiput.

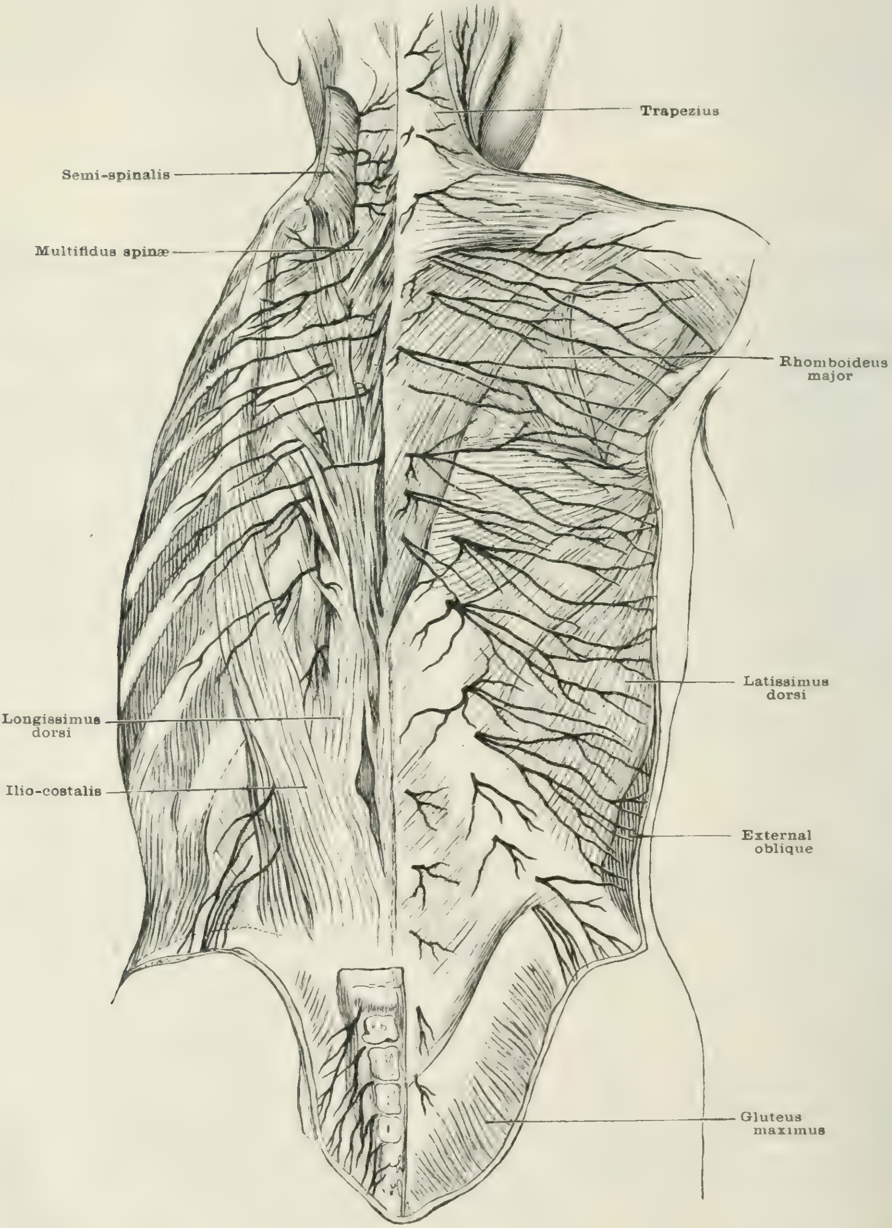
The **external branches** are distributed to the trachelo-mastoid, the cervicalis ascendens, the transversalis colli, and to the splenius.

The **internal branches** of the sixth, seventh, and eighth cervical nerves pass under cover of the semispinalis colli, and end in that muscle and in the adjacent part of the multifidus spinæ. The **external branches** are distributed to the complexus, splenius, cervicalis ascendens, and transversalis colli muscles.

The **posterior primary division of the first cervical nerve** passes backwards between the posterior arch of the atlas and the vertebral artery, and traverses the fatty tissue which occupies the triangular space bounded by the obliquus superior, the obliquus inferior, and the rectus capitis posticus major. It gives a branch to each of these three muscles, and a twig which crosses the superficial surface of the rectus capitis posticus major to reach the rectus capitis posticus minor. Another twig forms a communicating loop with the great occipital nerve on the posterior surface of the obliquus inferior. A branch is also furnished to the complexus. In a few cases it gives a cutaneous twig to the back of the occiput.

The **posterior division of the second cervical nerve** divides into a small external and a very large internal branch. The external branch gives a twig to the obliquus inferior, and ends in the complexus and trachelo-mastoid muscles. The internal branch is the **great occipital nerve.** It gives off communicating branches which pass upwards and downwards, forming loops with the first and third cervical nerves. In this manner a small plexus (posterior cervical plexus of Cruveilhier) is formed. The great occipital nerve is then directed upwards, crossing the triangular space described in connection with the first nerve, and being covered by the complexus. It gives one or two twigs to the latter muscle, and then pierces it to reach the deep surface of the trapezius. It pierces the outer border of the trapezius immediately below the superior curved line, and divides at acute angles into a number of branches, which ramify in the scalp. These branches communicate freely with the lesser occipital nerve, and run in the subcutaneous fat between the skin and the occipito-frontalis. In this situation they are accompanied by branches of the occipital artery. They supply the integument which covers the portion of the occipital bone above the superior curved line, and the posterior part of the parietal bone. One of them occasionally reaches the pinna and supplies the skin on the upper part of its inner aspect.

FIG. 452.—DISTRIBUTION OF THE POSTERIOR PRIMARY DIVISIONS OF THE SPINAL NERVES. (Henle.)


Trapezius
Semi-spinalis
Multifidus spinæ
Rhomboideus major
Latissimus dorsi
Longissimus dorsi
Ilio-costalis
External oblique
Gluteus maximus

THORACIC NERVES.—The posterior primary divisions of the thoracic nerves pass backwards between the transverse processes of the thoracic vertebræ, and divide into internal and external branches. The internal branches become progressively smaller from the second to the last of the series. The external branches show a reciprocal increase in size.

The **internal branches** pass to the inner side of the longissimus dorsi, giving branches to that muscle and to the spinalis dorsi, semispinalis, multifidus spinæ, rotatores spinæ, intertransversales, and interspinales. Large branches from the upper six or seven nerves reach the surface by piercing the origin of the trapezius close to the spinous processes of the vertebræ. They run outwards in the superficial fascia, and supply the integument of the back, including the skin over the inner half of the infraspinous part of the dorsum scapulæ and the integument over the supraspinous fossa. The cutaneous branch of the second nerve is the largest of the series. From the lower five or six nerves small twigs usually reach the surface and become cutaneous.

The **external branches** of the upper six or seven nerves end in the accessorius and longissimus dorsi muscles. The lower five or six, after supplying the adjacent muscles, pierce the outer series of insertions of the longissimus dorsi, and appear in the interval between that muscle and the accessorius. They then pierce the latissimus dorsi, and are distributed to the integument on the lower and outer part of the back.

LUMBAR NERVES.—The **internal branches** of all the lumbar nerves end in the multifidus spinæ.

The **external branches of the upper three nerves,** after supplying twigs to the adjacent muscles, pierce the posterior layer of the lumbar aponeurosis at the outer border of the erector spinæ. The three nerves cross the crest of the ilium and occupy different planes in the thick superficial fascia which covers the upper part of the gluteus medius. The branch from the first nerve is comparatively small, and occupies the most superficial plane. The second occupies an intermediate position. The branch from the third nerve is the largest of the three, and occupies the deepest position; it distributes branches over the gluteus maximus as far as the great trochanter. The three nerves communicate with one another and also with the cutaneous branches from the posterior divisions of the two upper sacral nerves. The **external branch of the fourth lumbar nerve** is of small size and ends in the lower part of the erector spinæ. The **external branch of the fifth lumbar** is distributed to the erector spinæ and communicates with the first sacral nerve.

SACRAL AND COCCYGEAL NERVES.—The posterior divisions of the upper four sacral nerves escape from the neural canal by passing through the posterior sacral foramina; the fifth sacral nerve passes between the sacrum and coccyx. The coccygeal nerve escapes through the termination of the neural canal. The upper three sacral nerves divide in the ordinary manner into internal and external branches, the lower two sacral and the coccygeal nerves remain undivided.

The **internal branches** of the upper three sacral nerves are of small size, and are distributed to the multifidus spinæ. The external branches unite with one another and with the external branch of the last lumbar nerve to form loops on the posterior surface of the sacrum. From these loops branches proceed to the posterior surface of the great sacro-sciatic ligament, where they communicate to form a second series of loops, whence two or three branches are given off. These branches pierce the gluteus maximus and come to the surface of that muscle in a line between the posterior superior spine of the ilium and the tip of the coccyx. They are distributed to the integument over the inner part of the gluteus maximus, and communicate, in their course through the superficial fascia, with the posterior branches of the lumbar nerves.

The posterior divisions of the **lower two sacral** and of the **coccygeal nerve** unite with one another and with the posterior branch of the third sacral, and form loops whence twigs pass to the integument over the lower end of the coccyx.

ANTERIOR PRIMARY DIVISIONS

The anterior divisions of the spinal nerves (with the two exceptions above mentioned) are larger than the posterior divisions, and each is connected by one or two rami communicantes with the ganglionated cord of the sympathetic. In the cervical, lumbar, sacral, and coccygeal regions they combine to form plexuses; in the thoracic region each nerve takes for the most part an independent course, and its typical division into a lateral or dorsal, and an anterior or ventral branch is very obvious. This division, however, is not confined to the dorsal nerves; it is recognisable, though with more difficulty, in the lower cervical, lumbar, and sacral regions, and it cannot be clearly distinguished in the upper cervical and coccygeal regions.

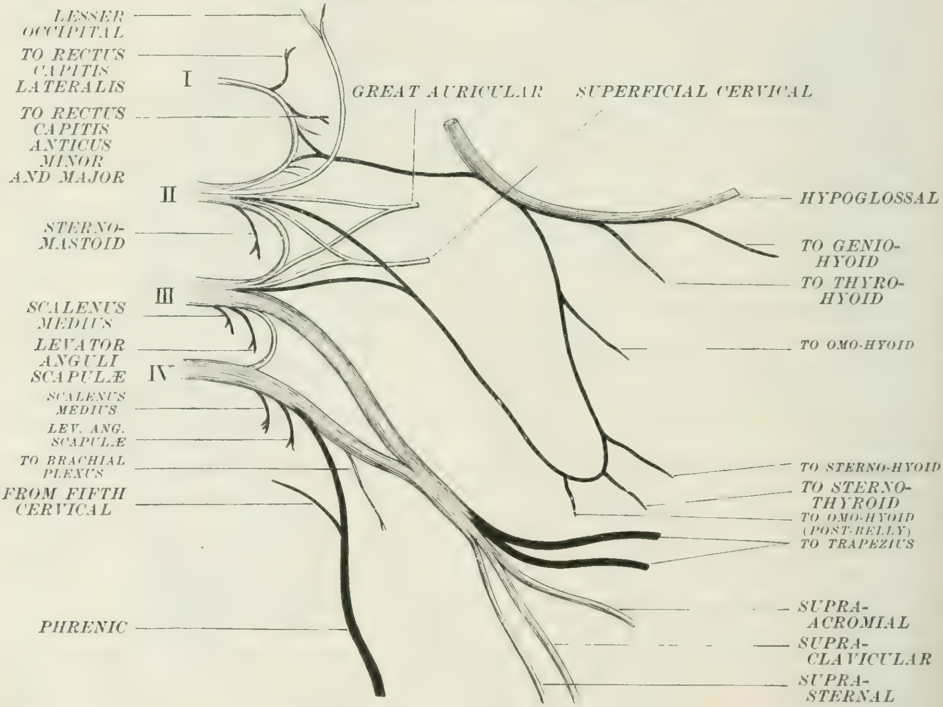

LESSER OCCIPITAL
TO RECTUS CAPITIS LATERALIS
I
TO RECTUS CAPITIS ANTICUS MINOR AND MAJOR
GREAT AURICULAR
SUPERFICIAL CERVICAL
II
HYPOGLOSSAL
STERNO-MASTOID
TO GENIO-HYOID
TO THYRO-HYOID
III
SCALENUS MEDIUS
LEVATOR ANGULI SCAPULÆ
TO OMO-HYOID
IV
SCALENUS MEDIUS
LEV. ANG. SCAPULÆ
TO BRACHIAL PLEXUS
FROM FIFTH CERVICAL
TO STERNO-HYOID
TO STERNO-THYROID
TO OMO-HYOID (POST-BELLY)
TO TRAPEZIUS
PHRENIC
SUPRA-ACROMIAL
SUPRA-CLAVICULAR
SUPRA-STERNAL

FIG. 453.—DIAGRAM OF THE CERVICAL PLEXUS.

CERVICAL NERVES.—The anterior primary divisions of the upper four cervical nerves are of moderate size; each is connected by one or two branches with the superior cervical ganglion of the sympathetic, and they unite with one another to form a looped plexus, the cervical plexus. The anterior primary division of the first cervical nerve, smaller than the posterior division, passes outwards in the groove on the posterior arch of the atlas beneath the vertebral artery, turns forwards between the vertebral artery and the lateral mass of the atlas, and bends downwards in front of the transverse process of that bone to unite with the second nerve. The anterior division of the second nerve runs outwards behind the superior articular process of the axis, passes behind and to the outer side of the vertebral artery and in front of the second posterior intertransverse muscle to the interval between the scalenus medius and the rectus capitis anticus major, where it unites with the first and third nerves. The anterior divisions of the third and fourth nerves, after their exits from the intervertebral foramina, pass behind the vertebral artery and between the anterior and posterior intertransverse muscles to appear in the interspace between the rectus capitis anticus major and the scalenus medius, where the third unites with the second and fourth nerves, completing the plexus.

The **lower four cervical nerves** increase rapidly in size from the fifth to the eighth, and unite with the greater part of the first thoracic nerve to form the brachial plexus. Each of these nerves is connected by one or two twigs to the cervical sympathetic.

CERVICAL PLEXUS

The anterior divisions of the **upper four cervical nerves** unite to form the cervical plexus in the following manner: the second and third nerves are connected by ascending and descending branches with one another, and with the first and fourth nerves. In this way a series of three loops is formed. The fourth nerve is also connected with the brachial plexus by a descending twig. The plexus lies in the upper part of the side of the neck, upon the scalenus medius muscle, and under cover of the upper part of the sterno-mastoid. The branches of the plexus are classified into a superficial and a deep series. The superficial series is subdivided into ascending, transverse, and descending branches; the deep series into external and internal branches.

Superficial Branches

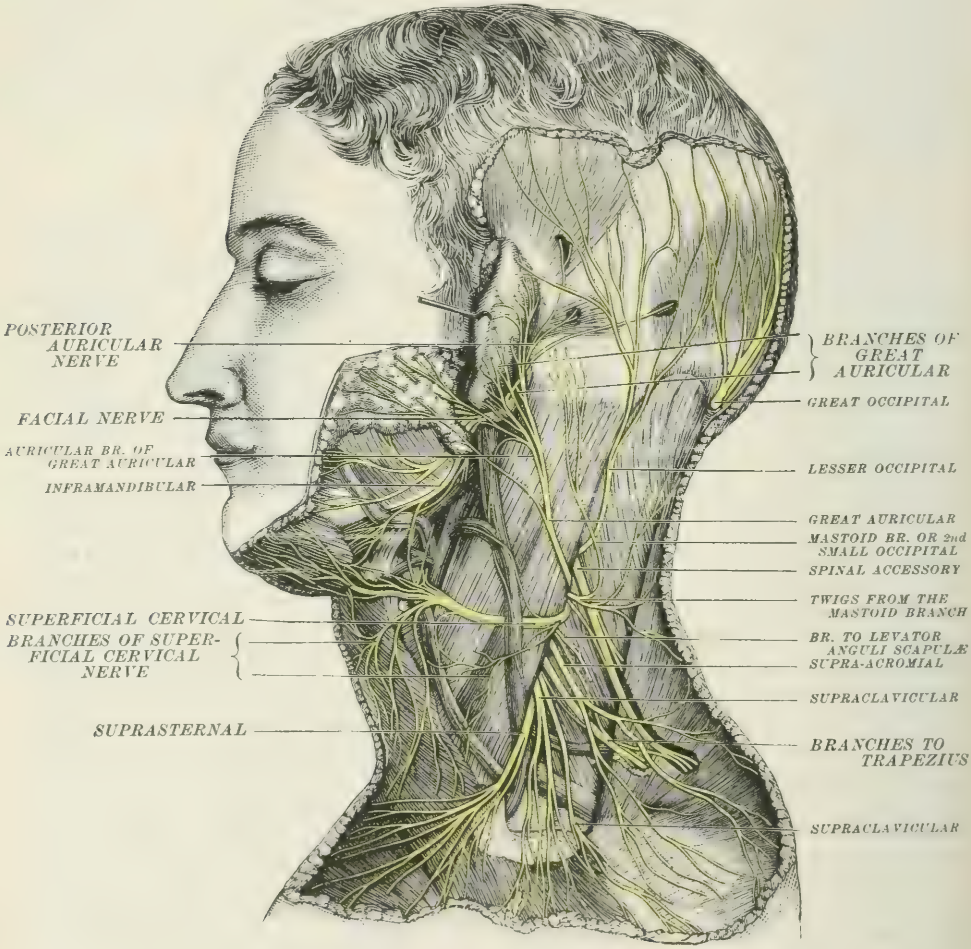
Ascending branches.—1. The **lesser occipital nerve** is derived from the second cervical. It passes backwards and slightly upwards under cover of the sterno-mastoid muscle to reach the posterior border of that muscle. It then ascends, running parallel to the posterior border of the muscle, being occasionally overlapped by it, and passes on to the scalp, where it divides into auricular, mastoid, and occipital branches. (*a*) The **auricular branch** runs upwards and slightly forwards to reach the integument on the posterior and upper part of the pinna, and is distributed there. (*b*) The **mastoid branch** is distributed to the skin covering the base of the mastoid process. (*c*) The **occipital branches** ramify over the occipitalis muscle, and are distributed to the skin of the scalp; they communicate with one another and with the great occipital nerve. The branches of the small occipital nerve anastomose with twigs of the posterior auricular, great auricular, and great occipital nerves.

2. The **great auricular nerve** arises by two roots, one from the second, and the other from the third cervical nerve. It accompanies the lesser occipital nerve as far as the posterior border of the sterno-mastoid, and then winds round that muscle, and crosses it obliquely. In this course it runs upwards and forwards towards the tip of the mastoid process, and is covered by the skin, superficial fascia, and platysma. At a point about the centre of its course across the sterno-mastoid muscle, it begins to divide into branches, which diverge from one another as they approach the level of the mastoid process, forming mastoid, auricular, and facial branches. (*a*) The **mastoid branch** is small, and is distributed to the integument covering the mastoid process. It anastomoses with the posterior auricular and small occipital nerves. (*b*) The **auricular branches** are three or four stout twigs which anastomose with the branches of the posterior auricular nerve; they cross the superficial surface of the posterior auricular branch of the facial, and are distributed to the skin on the back of the pinna with the exception of its uppermost part. One or two twigs pass through fissures in the cartilage of the ear, and are distributed to the integument on the outer surface of the lobule and the outer surface of the lower part of the helix and antihelix. (*c*) The **facial** branches pass upwards and forwards among the superficial lobules of the parotid and supply the skin over that gland and immediately in front of it, and they anastomose in the substance of the gland with the cervico-facial division of the facial nerve. In some cases fine twigs may be traced forwards nearly to the angle of the mouth.

Transverse branch.—The **superficial cervical nerve** arises from the second and third nerves, and appears at the posterior border of the sterno-mastoid, a little below the great auricular nerve. It passes transversely across the sterno-mastoid under cover of the integuments, platysma, and external jugular vein. It divides into a number of twigs which spread out after the manner of a fan, and extend, as they approach the middle line, from the chin to the sternum. The upper two or three of these twigs unite, beneath the platysma, with the infra-mandibular branch of the facial, and thus form loops. From the terminal branches of the nerve numerous twigs pierce the platysma to end in the skin of the front part of the neck.

Descending branches.—These are derived from the third and fourth cervical nerves, and arise under cover of the sterno-mastoid. At their commencement they are usually united with the muscular branches destined for the trapezius. They become superficial at the posterior border of the sterno-mastoid, about the centre of that muscle, and are termed supra-sternal, supra-clavicular, and supra-acromial nerves. (1) The **supra-sternal twigs** are small, and cross over the clavicular origin of the sterno-mastoid to reach the integument over the upper part of the manubrium sterni. They also supply the sterno-clavicular joint. (2) The **supra-clavicular nerves,** of considerable size, cross in front of the middle third of the clavicle under cover of the platysma, and are distributed to the skin, covering the upper part of the pectoralis major as low as the third rib. (3) The **supra-acromial branches** cross the clavicular insertion of the trapezius and the acromion

FIG. 454.—SUPERFICIAL BRANCHES OF THE CERVICAL PLEXUS. (After Hirschfeld and Leveillé.)


POSTERIOR AURICULAR NERVE
FACIAL NERVE
AURICULAR BR. OF GREAT AURICULAR
INFRAMANDIBULAR
SUPERFICIAL CERVICAL
BRANCHES OF SUPERFICIAL CERVICAL NERVE
SUPRASTERNAL
BRANCHES OF GREAT AURICULAR
GREAT OCCIPITAL
LESSER OCCIPITAL
GREAT AURICULAR
MASTOID BR. OR 2nd SMALL OCCIPITAL
SPINAL ACCESSORY
TWIGS FROM THE MASTOID BRANCH
BR. TO LEVATOR ANGULI SCAPULÆ
SUPRA-ACROMIAL
SUPRACLAVICULAR
BRANCHES TO TRAPEZIUS
SUPRACLAVICULAR

process, and are distributed to the skin which invests the upper two-thirds of the deltoid muscle. They supply the acromio-clavicular joint.

Deep Branches

External branches.—These consist of communicating branches from the second and third cervical nerves to the spinal accessory, and of muscular branches which supply the sterno-mastoid, scalenus medius, levator anguli scapulæ, and trapezius.

1. The **nerve to the sterno-mastoid** arises from the second cervical nerve. It pierces the deep surface of the sterno-mastoid, and communicates within the muscle with the spinal accessory nerve.

2. The **nerves to the scalenus medius** are derived from the third and fourth cervical nerves close to their exit from the intervertebral foramina.

3. The **nerves to the levator anguli scapulæ** are derived from the third and fourth nerves, and occasionally from the second. They pierce the superficial surface of the levator anguli, and supply the upper three divisions of that muscle.

4. The **branches to the trapezius** are usually in the form of two stout twigs which are given off by the third and fourth cervical nerves. They emerge at the posterior border of the sterno-mastoid, and cross the posterior superior triangle of the neck at a lower level than the spinal accessory nerve. They pass under cover of the trapezius in company with the last-named nerve, and communicate with it to form the **subtrapezial plexus,** from which the trapezius is supplied.

Internal branches.—The internal set of deep branches comprise communicating branches and muscular branches. 1. The **communicating branches** pass to the vagus and hypoglossal nerves, from the loop formed by the first and second nerves, and to the sympathetic from all of the four nerves which enter into the cervical plexus. The **muscular branches** are distributed to the rectus capitis lateralis, to the recti capitis antici major and minor, to the longus colli, to the depressors of the hyoid bone (communicantes hypoglossi), and to the diaphragm (phrenic nerve).

2. The **branch to the rectus capitis lateralis** is furnished to that muscle by the first nerve as it crosses the deep surface of the muscle.

3. The **nerve to the rectus capitis anticus minor** is given off by the first nerve at the upper part of the loop in front of the transverse process of the atlas.

4. The **rectus capitis anticus major** receives twigs from the upper four cervical nerves.

5. The **longus colli** receives branches from the second, third, and fourth cervical nerves, and additional branches also from the fifth and sixth nerves.

6. The **communicantes hypoglossi** are given off by the second and third cervical nerves, and run obliquely downwards and inwards in front of the great vessels of the neck to form a loop, the **ansa hypoglossi,** with the so-called descendens hypoglossi. They supply the depressor muscles of the hyoid bone. (See Hypoglossal Nerve.)

7. The **PHRENIC NERVE** may arise by one, two, or three roots, the strongest, and occasionally the only, root being derived from the fourth cervical nerve. A root from the fifth is commonly present, and is usually associated either with the nerve to the subclavius or with the communicating branch which passes from the cervical to the brachial plexus. A slender root from the third nerve is occasionally present. The cervical sympathetic also furnishes a communicating twig. The phrenic nerve passes downwards and inwards under cover of the sterno-mastoid, crossing obliquely in front of the scalenus anticus muscle. It is crossed by the transverse cervical and suprascapular arteries, and also by the omo-hyoid muscle. It passes behind the subclavian vein, and enters the thorax. In this situation it crosses in front of or behind the commencement of the internal mammary artery, and is commonly joined at this point by a communicating twig from the nerve to the subclavius muscle. On the left side it is crossed, in addition, by the terminal part of the thoracic duct.

The further course of the phrenic differs on the two sides. On the **right side** the nerve passes downwards, running on the outer side of the right innominate vein, the superior vena cava, and the pericardium, between these structures and the pleura. In its course between the pericardium and pleura it crosses in front of the root of the lung. It then pierces the diaphragm immediately on the left side of the opening for the vena cava inferior, and is distributed to the diaphragm, the branches entering the muscle on its lower surface. On the **left side** the phrenic nerve passes on to the left side of the aortic arch, between the latter and the pleura, and in front of the inferior cervical cardiac branch of the vagus. It then runs downwards between the pericardium and the pleura in front of the root of the lung, taking a longer course than on the right side in consequence of the inclination of the heart to the left side, and also on account of the lower level of the left cupola of the diaphragm. It pierces the diaphragm immediately to the left of the attachment of the pericardium to that muscle, and is distributed to its abdominal surface in a similar manner to the nerve on the right side.

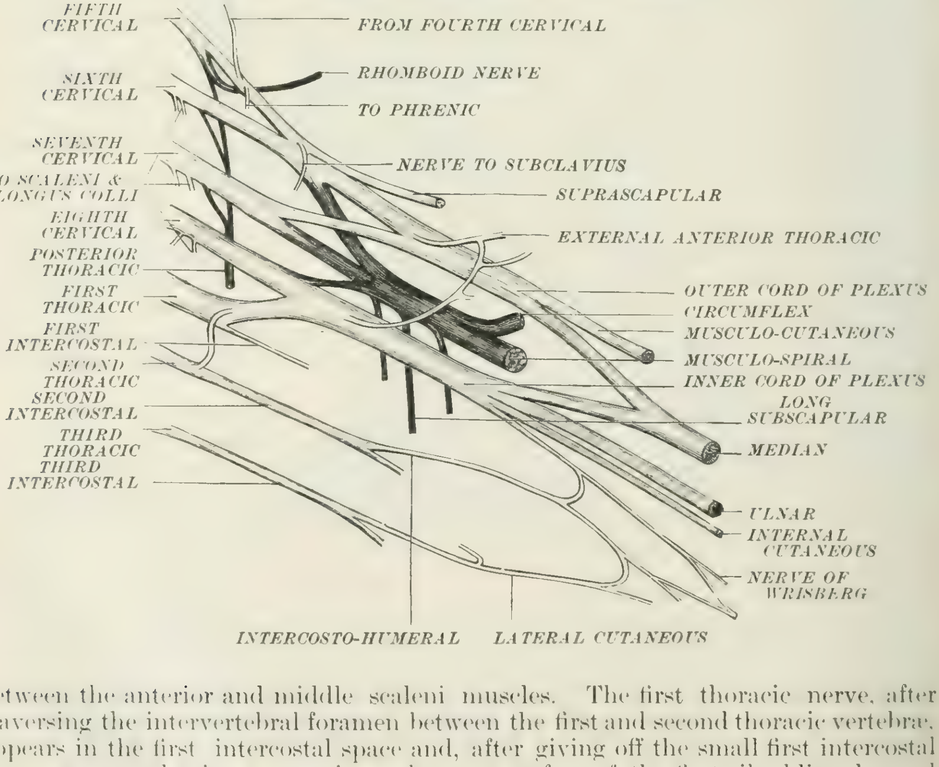
Branches.—Minute twigs are supplied (*a*) to the pleura; and (*b*) to the pericardium. On the right side the nerve communicates with the diaphragmatic plexus of the sympathetic, forming a small ganglion (**ganglion diaphragmaticum**).

BRACHIAL PLEXUS

The **BRACHIAL PLEXUS** is formed by the anterior primary divisions of the **four lower cervical nerves** and the greater part of the **first thoracic nerve**; it is usually joined by small communicating twigs from the **fourth cervical** and **second thoracic nerves.** The four lower cervical nerves emerge in the interval between the anterior and middle scaleni muscles. The first thoracic nerve, after traversing the intervertebral foramen between the first and second thoracic vertebræ, appears in the first intercostal space and, after giving off the small first intercostal nerve, crosses the inner margin and upper surface of the first rib obliquely, and joins the eighth cervical nerve.

FIG. 455.—DIAGRAM OF THE BRACHIAL PLEXUS.

The posterior cord of the plexus is darkly shaded.


FIFTH CERVICAL
FROM FOURTH CERVICAL
RHOMBOID NERVE
SIXTH CERVICAL
TO PHRENIC
SEVENTH CERVICAL
NERVE TO SUBCLAVIUS
TO SCALENI & LONGUS COLLI
SUPRASCAPULAR
EIGHTH CERVICAL
EXTERNAL ANTERIOR THORACIC
POSTERIOR THORACIC
FIRST THORACIC
OUTER CORD OF PLEXUS
CIRCUMFLEX
FIRST INTERCOSTAL
MUSCULO-CUTANEOUS
SECOND THORACIC
MUSCULO-SPIRAL
INNER CORD OF PLEXUS
SECOND INTERCOSTAL
LONG SUBSCAPULAR
THIRD THORACIC
MEDIAN
THIRD INTERCOSTAL
ULNAR
INTERNAL CUTANEOUS
NERVE OF WRISBERG
INTERCOSTO-HUMERAL
LATERAL CUTANEOUS

The brachial plexus is divisible into four distinct stages. In the first stage all the component nerves are separate from each other. In the second stage the nerves unite with one another to form **three trunks.** In the third stage the trunks divide into **anterior** and **posterior divisions.** In the fourth stage the six divisions become collected into three rounded bundles, which are termed **cords.**

The fifth and sixth, and usually a communicating twig from the fourth, cervical nerves unite to form the **upper trunk**; the seventh remains independent and forms the **middle trunk**; the eighth cervical and first thoracic, with occasionally a communicating twig from the second thoracic, unite to form the **lower trunk.** Each of these trunks divides into an anterior and a posterior division. The anterior and posterior divisions of the upper and middle trunks are about equal in size. The anterior division of the lower trunk is very much larger than the posterior division. The three posterior divisions unite to form the **posterior cord.** The anterior divisions of the upper and middle trunks join to form the **outer cord.** The anterior division of the lower trunk is continued into the **inner cord.**

The **first stage of the plexus** is situated upon the middle scalene in the posterior triangle of the neck. The **second stage** is placed in the posterior inferior triangle of the neck, the lower trunk of the plexus being behind the third stage of the subclavian artery and the upper and middle trunks above and on a plane posterior to that vessel. When a posterior scapular artery arises from the third stage of the subclavian, it passes backwards between the trunks of the plexus. In its **third stage** the plexus lies under cover of the clavicle and subclavius muscle, and is placed above, external, and on a plane posterior to the axillary artery. In its **fourth stage** the plexus is situated under cover of the pectoral muscles, and the cords surround the second stage of the axillary artery, occupying the positions indicated by their names, the external cord being in contact with the outer side of the artery, the internal cord on the inner side, and the posterior cord behind the vessel. A little external to the outer border of the pectoralis minor, the plexus terminates by dividing into large nerves, which surround the third stage of the axillary artery.

The branches of the brachial plexus are classified into branches which arise above the clavicle, and branches which are given off below that bone. The branches which arise below the clavicle may be conveniently subdivided into short branches which end in the axilla, and long branches which arise from the terminations of the three cords and are destined to supply the shoulder, arm, forearm, and hand.

Branches given off above the Clavicle

These are all muscular branches, and comprise the following nerves:—(1) Suprascapular; (2) rhomboid; (3) posterior thoracic; (4) communicating to the phrenic; nerves to (5) the subclavius, (6) scaleni, and (7) longus colli.

(1) The **suprascapular nerve** arises from the upper trunk of the plexus, and therefore contains fibres derived from the fifth and sixth, and in some cases from the fourth, cervical nerves. It runs downwards and outwards, crosses internal to the posterior belly of the omo-hyoid muscle, and passes under cover of the trapezius to reach the suprascapular notch; here it crosses the suprascapular artery, and takes a lower position than that vessel. It then passes through the suprascapular notch beneath the transverse ligament, and, after furnishing a twig to the shoulder joint, divides into a supraspinous and an infraspinous branch. The supraspinous branch inclines inwards and ends in the supraspinatus muscle. The infraspinous branch passes through the great scapular notch under cover of the spino-glenoid ligament, and terminates in the infraspinatus muscle.

(2) The **nerve to the rhomboids** arises from the fifth cervical nerve shortly after its exit from the intervertebral foramen. It arises in common with the upper root of the posterior thoracic nerve, and passes backwards and outwards through the fibres of the scalenus medius. It then usually divides in a plexiform manner into several branches, the strongest of which passes below the levator anguli scapulæ, while the others traverse the lowest division of that muscle and supply it with one or more twigs. In the cellular interval between the levator and the rhomboideus minor, the twigs reunite to form one nerve, which passes to the deep surface of the two rhomboid muscles and supplies them.

(3) The **posterior thoracic nerve** (external respiratory of Bell) arises, by three roots, from the fifth, sixth, and seventh cervical nerves. The upper two roots traverse the substance of the scalenus medius; the root from the seventh passes in front of that muscle. Twigs are furnished to the superior portion of the serratus magnus by the upper two roots; lower down they unite and are subsequently joined by the root from the seventh. The nerve now passes downwards behind the brachial plexus and the first stage of the axillary artery, and runs along the axillary surface of the serratus magnus, supplying twigs to each of the digitations of that muscle.

(4) The **communicating twig to the phrenic** arises from the fifth nerve close to the point where the latter nerve receives the communicating twig from the cervical plexus.

(5) The **nerve to the subclavius** is a small twig which arises from the fifth nerve or from the upper trunk of the plexus. Its fibres are derived from the fifth or in some cases from the fourth cervical nerve through the communicating twig from the cervical plexus. It run downwards in front of the third stage of the subclavian artery and, after giving off a communicating branch to the phrenic, pierces the posterior layer of the costo-coracoid membrane, and enters the subclavius at the lower border of that muscle.

Variety.—In rare cases the entire phrenic nerve may pass *viâ* the nerve to the subclavius in front of the third stage of the subclavian artery.

(6) The *scaleni* and (7) *longus colli* are supplied by twigs which arise from the lower two or three cervical nerves immediately after their exit from the intervertebral foramina.

Branches given off below the Clavicle

The **AXILLARY** or **SHORT BRANCHES** are (1) the external and (2) internal anterior thoracic, and (3) the three subscapular nerves.

(1) The **external anterior thoracic nerve** arises from the outer cord of the plexus; it contains fibres from the fifth, sixth and seventh nerves. After communicating with the internal anterior thoracic, it pierces the costo-coracoid membrane and ends in branches which supply the pectoralis major.

(2) The **internal anterior thoracic nerve** arises from the inner cord and passes forwards between the first stage of the axillary artery and the axillary vein. It contains fibres of the eighth cervical and first dorsal nerves, and it gives branches to the pectoralis minor, some of which pass through the latter muscle and end in the great pectoral. The nerve then unites with a branch from the external anterior thoracic, and forms a loop which is placed in front of the first stage of the axillary artery. From this loop additional branches are furnished to the greater pectoral muscle.

(3) The **subscapular nerves** are branches of the posterior cord. They are three in number, are distinguished as upper, middle, and lower, and are distributed to the subscapularis, latissimus dorsi, and teres major muscles.

(*a*) The **upper** or **short subscapular nerve** is derived from the fifth and sixth cervical nerves. It is distributed exclusively to the subscapularis muscle. It is occasionally double.

(*b*) The **middle** or **long subscapular nerve** contains fibres of the seventh cervical nerve; it accompanies the subscapular artery along the axillary margin of the subscapularis muscle and ends in the latissimus dorsi.

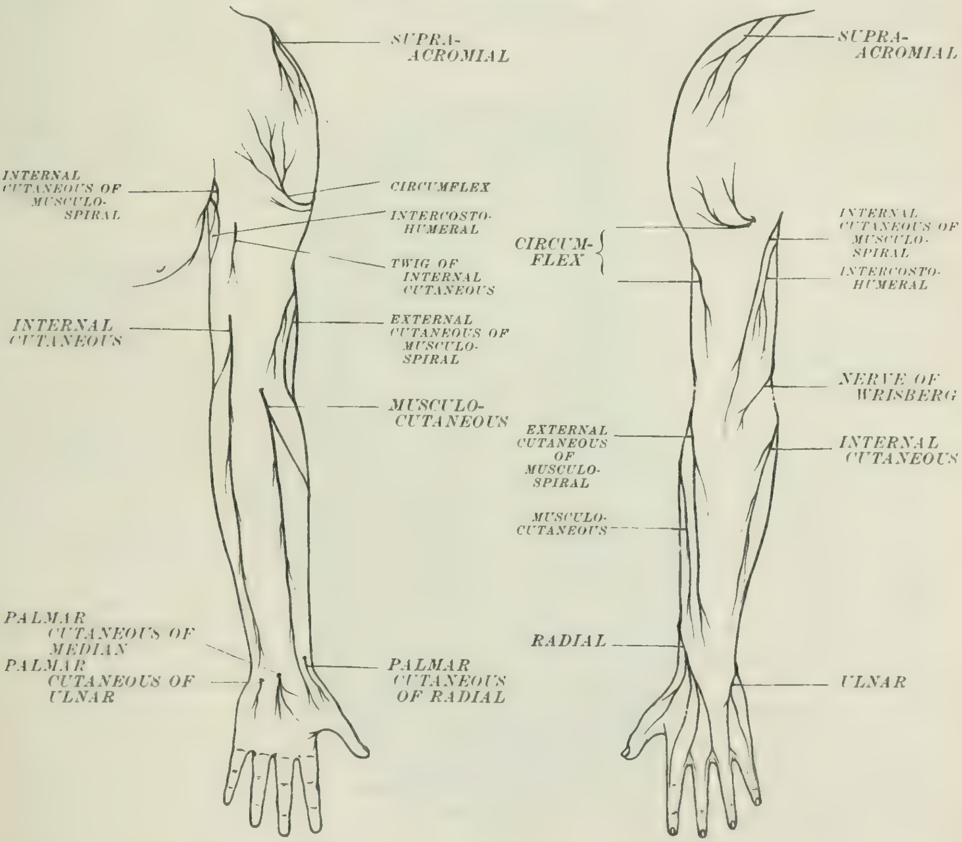
(*c*) The **lower subscapular nerve**, carrying fibres of the fifth and sixth cervical nerves, passes behind the subscapular artery, below the dorsalis scapulæ branch, and is distributed to the teres major; furnishing one or two twigs to the subscapularis, which enter the subscapularis near the axillary margin of that muscle.

TERMINAL OR LONG BRANCHES.—These are given off as follows: from the **outer cord,** the musculo-cutaneous and the outer head of the median; from the **inner cord,** the inner head of the median, the ulnar, the internal cutaneous, and the lesser internal cutaneous; from the **posterior cord,** the musculo-spiral and the circumflex nerves. The circumflex, lesser internal cutaneous, internal cutaneous, and musculo-cutaneous are more proximal in their distribution than the median, ulnar, and musculo-spiral, and may therefore be first described.

(1) The **circumflex nerve** is a branch of the posterior cord, and is composed of fibres derived from the fifth and sixth cervical nerves. It accompanies the posterior circumflex artery through the quadrilateral space bounded by the teres major, long head of triceps, and subscapularis muscles, and by the surgical neck of the humerus, and it divides into a smaller posterior and a larger anterior division. Previous to its division it furnishes an articular twig to the shoulder joint. This twig pierces the inferior part of the capsular ligament.

(*a*) The **anterior division** accompanies the posterior circumflex artery around the neck of the humerus, and gives off a number of stout twigs which enter the deltoid muscle. A few fine filaments pierce the deltoid and end in the integument which covers the middle third of that muscle.

FIG. 456.—DISTRIBUTION OF CUTANEOUS NERVES ON THE ANTERIOR AND POSTERIOR ASPECTS OF THE SUPERIOR EXTREMITY.


SUPRA-ACROMIAL
INTERNAL CUTANEOUS OF MUSCULO-SPIRAL
CIRCUMFLEX
INTERCOSTO-HUMERAL
TWIG OF INTERNAL CUTANEOUS
INTERNAL CUTANEOUS
EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
MUSCULO-CUTANEOUS
PALMAR CUTANEOUS OF MEDIAN
PALMAR CUTANEOUS OF ULNAR
PALMAR CUTANEOUS OF RADIAL
SUPRA-ACROMIAL
INTERNAL CUTANEOUS OF MUSCULO-SPIRAL
CIRCUM-FLEX
INTERCOSTO-HUMERAL
NERVE OF WRISBERG
INTERNAL CUTANEOUS
EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
MUSCULO-CUTANEOUS
RADIAL
ULNAR

(*b*) The **posterior division** divides into cutaneous and muscular branches. The cutaneous branch supplies the skin covering the lower third of the deltoid and a small area of integument below the insertion of that muscle. One muscular branch is distributed to the teres minor; it swells out into an ovoid or fusiform reddish gangliform enlargement before entering the muscle, others supply the lower and posterior part of the deltoid.

(2) The **lesser internal cutaneous nerve**, or **nerve of Wrisberg**, arises from the inner cord of the brachial plexus, and is formed of fibres derived from the eighth cervical and first thoracic nerves or from the first thoracic nerve alone. It runs downwards on the inner side of the axillary vein, being separated by that

vessel from the ulnar nerve. It passes downwards with a slight inclination backwards under cover of the deep fascia on the inner side of the arm. At the middle of the arm it pierces the fascia, and near the bend of the elbow it turns somewhat sharply backwards to supply the integument which covers the olecranon process. As it traverses the axilla the nerve of Wrisberg communicates with the intercosto-humeral nerve forming one or sometimes two loops. In its course down the arm it gives a few fine twigs to the integument.

(3) The **internal cutaneous** is a branch of the inner cord, its fibres being ultimately derived from the eighth cervical and first thoracic nerves. At its origin it lies on the inner side of the axillary artery, but it soon passes forwards and lies in the groove between the artery and the vein anteriorly. In the upper two-thirds of the arm it lies in front and to the inner side of the brachial artery.

It then pierces the deep fascia in company with the basilic vein, and divides into an anterior and a posterior branch. Previous to its division it gives off a twig which pierces the deep fascia, and supplies the integument of the upper and inner part of the arm. (*a*) The **anterior branch** is larger than the posterior, and divides at acute angles into several twigs, some of which pass in front of and some behind the median basilic vein, and then run down the forearm to supply the integuments covering its anterior and internal aspect as far as the wrist, anastomosing with the branches of the ulnar nerve. (*b*) The **posterior branch** passes downwards and backwards in front of the internal condyle of the humerus, and divides into branches which supply the skin on the postero-internal aspect of the forearm. It anastomoses with the inferior external cutaneous branch of the musculo-spiral nerve and the dorsal branch of the ulnar nerve.

(4) The **musculo-cutaneous nerve** is a branch of the outer cord of the brachial plexus. It is composed of fibres which are derived from the fifth, sixth, and seventh cervical nerves. It is placed at first close to the outer side of the brachial artery, but soon leaves that vessel and pierces the coraco-brachialis muscle in a direction obliquely downwards and outwards. Continuing this oblique direction, it passes between the biceps and brachialis anticus muscles, and becomes superficial at the outer border of the former muscle, a little above the bend of the elbow. It then passes on the deep surface of the median cephalic vein, and divides into an anterior and a posterior branch. Previous to its division, the musculo-cutaneous nerve supplies three muscles, viz. the *coraco-brachialis*, the *biceps*, and the *brachialis anticus*. It also supplies twigs to the humerus, the nutrient artery, and the elbow-joint. The **nerve to the coraco-brachialis** consists of two or three twigs which are given off from the nerve close to its origin, and before it has traversed the muscle. In the child this branch rises separately from the seventh cervical nerve. The **nerves to the biceps and brachialis anticus muscles** arise from the musculo-cutaneous nerve as it is passing between these muscles. There is a separate branch for each head of the biceps. The **posterior terminal branch** is small, and is directed downwards and backwards in front of the external condyle of the humerus to be distributed to the skin on the outer and posterior aspect of the forearm as low as the wrist. It anastomoses with the radial nerve and with the inferior external cutaneous branch of the musculo-spiral nerve. The **anterior branch** runs downwards on the outer and anterior part of the forearm, supplying the integument of that region, and having communicated near the wrist with the radial nerve, it sends a branch through the deep fascia which accompanies the radial artery to the back of the wrist; it terminates in the skin covering the middle part of the thenar eminence.

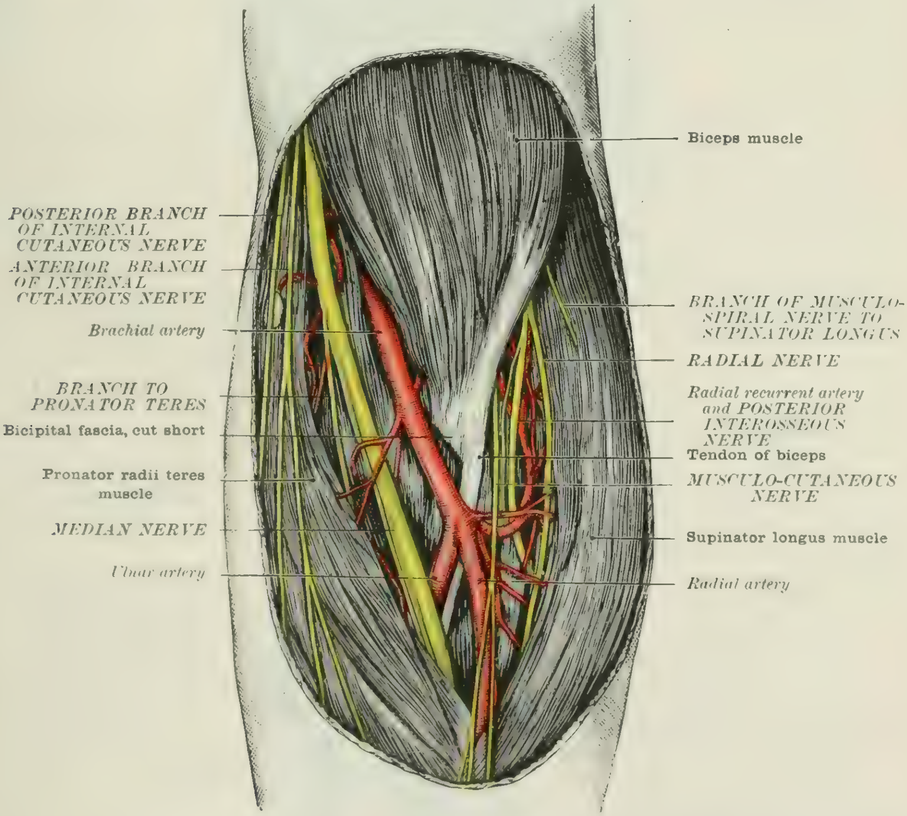
(5) The **median nerve** is formed by fibres derived from the fifth, sixth, seventh, and eighth cervical and first thoracic nerves. It arises by two heads, one from the outer, and one from the inner cord. The inner head crosses obliquely in front of the third stage of the axillary artery, and joins the outer head on the external side of that vessel. The median nerve runs almost vertically down the arm under cover of the skin and fascia, and is partially overlapped by the biceps. In the upper part of the arm it is placed on the outer side of the brachial artery. About the middle of the arm it crosses in front of that vessel, and then runs down on the inner side of the artery to the bend of the elbow. It then passes between the two heads of the pronator radii teres, and is separated from the ulnar artery in

this situation by the deep head of the muscle. It continues vertically downwards in the middle line of the forearm between the flexor sublimis and flexor profundus digitorum; in this part of its course it is accompanied by a companion artery, the comes nervi mediani. At the upper border of the annular ligament it is placed between the tendons of the flexor carpi radialis externally and the palmaris longus and flexor sublimis digitorum muscle internally. It passes under cover of the anterior annular ligament, on the superficial surface of the flexor tendons, and, at the lower border of the ligament, it enlarges, and bifurcates into two terminal divisions, an inner larger, and an outer smaller.

Branches.—The median nerve does not supply any part of the upper arm. In front of the elbow-joint it furnishes one or two filaments to the articulation. In the forearm it supplies all the superficial anterior muscles (with the exception of the flexor carpi ulnaris) directly from its trunk, and supplies the deep muscles (with the exception of the inner half of the flexor profundus) by its anterior interosseous branch. In the hand it supplies the group of short muscles of the thumb (with the exception of those which are placed on the ulnar side of the tendon of the flexor longus pollicis), the two outer lumbricales, the integument covering the central part of the palm and inner part of the thenar eminence, and the palmar aspect of the thumb, index, middle, and radial half of the ring fingers. It also sends twigs to the dorsal aspect of these digits.

FIG. 457.—A DISSECTION SHOWING THE ARRANGEMENT OF THE NERVES IN FRONT OF THE ELBOW.

(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)

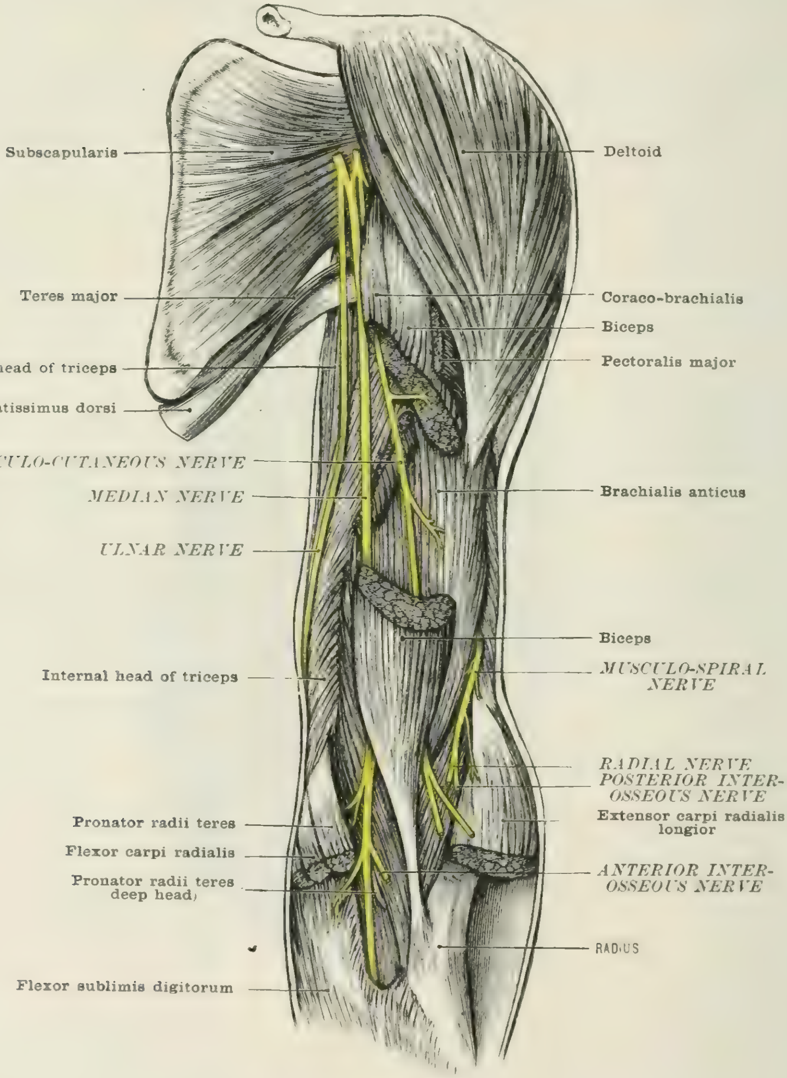

Biceps muscle
POSTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
ANTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
Brachial artery
BRANCH OF MUSCULO-SPIRAL NERVE TO SUPINATOR LONGUS
RADIAL NERVE
BRANCH TO PRONATOR TERES
Radial recurrent artery and POSTERIOR INTEROSSEOUS NERVE
Bicipital fascia, cut short
Tendon of biceps
Pronator radii teres muscle
MUSCULO-CUTANEOUS NERVE
MEDIAN NERVE
Supinator longus muscle
Ulnar artery
Radial artery

(*a*) The **nerve to the pronator radii teres** arises a little above the bend of the elbow, and pierces the outer border of that muscle.

(*b*) The **nerves to the flexor carpi radialis, palmaris longus,** and **flexor sublimis digitorum** arise a little lower down, and pierce the pronator-flexor mass of muscles, to end in the respective members of the group for which they are destined.

(*c*) The **anterior interosseous nerve** arises from the median at the level of the bicipital tubercle of the radius and run downwards on the interosseous membrane accompanied by the anterior interosseous artery. It passes under cover of the pronator quadratus, and pierces the deep surface of that muscle. The anterior interosseous nerve also furnishes a twig to the front of the wrist-joint and supplies the flexor profundus digitorum and the flexor longus pollicis. The nerve to the former muscle arises from the anterior interosseous near its commencement and supplies the outer two divisions of the muscle, and communicates within its substance with twigs derived from the ulnar nerve.

Fig. 457a.—Dissection of the Left Arm from the Front, Showing Portions of the Ulnar, Median, Musculo-cutaneous, and Musculo-spiral Nerves.

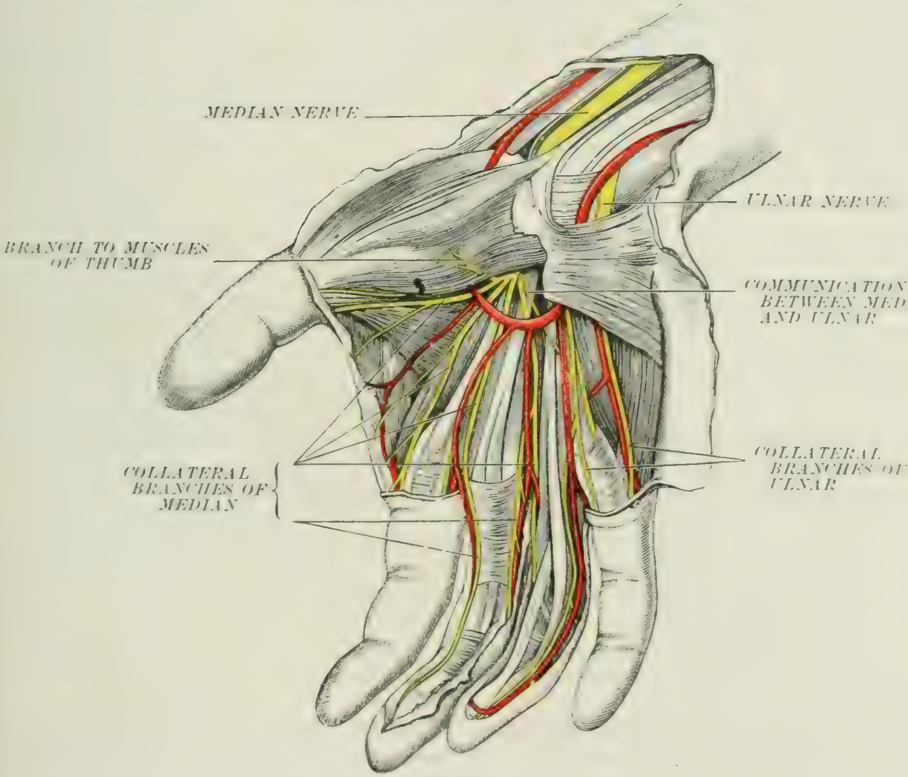

Subscapularis
Deltoid
Teres major
Coraco-brachialis
Biceps
Pectoralis major
Long head of triceps
Latissimus dorsi
MUSCULO-CUTANEOUS NERVE
MEDIAN NERVE
Brachialis anticus
ULNAR NERVE
Biceps
Internal head of triceps
MUSCULO-SPIRAL NERVE
RADIAL NERVE
POSTERIOR INTEROSSEOUS NERVE
Extensor carpi radialis longior
Pronator radii teres
Flexor carpi radialis
Pronator radii teres (deep head)
ANTERIOR INTEROSSEOUS NERVE
RADIUS
Flexor sublimis digitorum

It also supplies a branch to the interosseous membrane which runs downwards upon, or in, the membrane supplying it and giving branches to the anterior interosseous and medullary arteries and to the periosteum of the radius and ulna.

(*d*) The **palmar cutaneous branch** arises immediately above the anterior annular ligament and passes between the tendons of the flexor carpi radialis and the palmaris longus. It then crosses the superficial surface of the annular ligament, is distributed to the integument and fascia on the central depressed surface of the palm, and supplies a few twigs to the inner border of the thenar eminence: these twigs communicate with the musculo-cutaneous and radial nerves.

(*e*) The **external terminal division** gives off a branch which supplies the abductor, the opponens, and the superficial head of the flexor brevis pollicis muscles, then it divides into two branches. The **outer branch** passes obliquely across the long flexor tendon of the thumb, and runs along the radial border of the thumb as far as its extremity. It gives numerous branches to the pulp of the thumb, and a strong twig which passes on to the dorsum to supply the matrix of the nail. The **inner branch,** after running a course varying from an eighth to a half an inch, divides into two digital collateral branches. The outer collateral branch supplies the ulnar side of the volar aspect of the thumb, and gives off a twig to the matrix of the thumb nail. The inner collateral branch is distributed in a similar manner to the radial side of the index finger. It gives off a twig to supply the first lumbrical muscle.

FIG. 458.—SUPERFICIAL NERVES OF THE PALM. (Ellis.)


MEDIAN NERVE
ULNAR NERVE
BRANCH TO MUSCLES OF THUMB
COMMUNICATION BETWEEN MEDIAN AND ULNAR
COLLATERAL BRANCHES OF MEDIAN
COLLATERAL BRANCHES OF ULNAR

(*f*) The **internal terminal division** divides into an outer and an inner branch. The **outer branch** gives a twig to supply the second lumbrical muscle, and divides a little above the metacarpo-phalangeal articulation into collateral branches, which supply the adjacent sides of the index and middle fingers, and also give twigs to the dorsum of each of these digits. These dorsal twigs will be more particularly described later on (page 797). The **inner branch** communicates with the ulnar nerve and divides to supply the adjacent sides of the middle and ring fingers.

As the branches of the median nerve pass downwards in the palm of the hand, they cross the deep or posterior surface of the superficial palmar arch. This relation to the arteries is reversed in the fingers, where the digital arteries are placed behind the nerves. As each digital nerve pursues its course along the margin of the corresponding finger, it gives off twigs to the dorsum of the finger, which supply the skin on the dorsum of the second and third phalanges, particularly stout twigs passing to supply the matrix of the nail. Each nerve terminates in branches to the pulp of the finger, and on these terminal branches as well as on the more proximal twigs to the volar aspect of the fingers, ovoid bodies, about the size of millet seeds, are developed. These bodies are called **Pacinian corpuscles**, and are one of the forms of sensory nerve-terminations.

(6) The **ulnar nerve** is the largest branch of the inner cord of the brachial plexus, and is derived from the eighth cervical and first thoracic nerves. It runs downwards between the axillary artery and the vein, posteriorly, and preserves the same relation to the brachial artery for the upper third of the arm. It then diverges from the brachial artery at an acute angle, and accompanies the inferior profunda artery through the internal muscular septum and downwards upon the inner head of the triceps to the interval between the internal condyle of the humerus and the olecranon processes of the ulna. In this course it is placed under cover of the deep fascia. It then passes between the two heads of the flexor carpi ulnaris, comes into relation with the posterior ulnar recurrent artery, and runs downwards under cover of the flexor carpi ulnaris muscle, between it and the flexor profundus digitorum, to reach the wrist. At the junction of the upper and middle thirds of the forearm it is joined, at an acute angle, by the ulnar artery, and runs parallel to the inner side of that vessel in the middle and lower two-thirds of the forearm under cover of the flexor carpi ulnaris, and between that muscle and the flexor sublimis digitorum. Just above the wrist it pierces the deep fascia, enters the hand by crossing the superficial surface of the anterior annular ligament close to the radial border of the pisiform bone, and terminates by bifurcating into a superficial and a deep division.

Branches.—The ulnar resembles the median nerve in not furnishing any branches to the upper arm. As it passes between the olecranon process and the internal condyle, it gives off two or three fine filaments to the elbow-joint. In the forearm it supplies the flexor carpi ulnaris and the inner portion of the flexor profundus digitorum, and gives off the three cutaneous branches. In the hand it supplies the integument of the hypothenar eminence, the little finger and half of the ring finger and part of the dorsum; it also gives twigs to the palm and supplies the short intrinsic muscles of the hand with the exception of the abductor, the opponens, the outer head of the flexor brevis pollicis, and the two outer lumbricales.

(*a*) The **nerves to the flexor carpi ulnaris** and to the inner two divisions of the **flexor profundus digitorum** arise from the ulnar in the upper third of the forearm.

(*b*) The **Palmar Cutaneous Branch.**—About the middle of the forearm it gives off two cutaneous branches; one pierces the fascia and anastomoses with the anterior branch of the internal cutaneous nerve, and the other, the palmar cutaneous branch, runs downwards in front of the ulnar artery, and is conducted by the vessel into the palm. It furnishes some filaments to the vessel, and ends in the integument covering the central depressed surface of the palm and supplies a few twigs to the skin of the hypothenar eminence.

(*c*) The **dorsal** or **posterior cutaneous branch** arises about two inches above the wrist-joint, and passes backwards under cover of the flexor carpi ulnaris to reach the dorsal aspect of the wrist. It crosses superficial to the tendon of the extensor carpi ulnaris immediately below the lower end of the ulna, and, after giving off twigs to supply the skin of the dorsum of the hand, divides into three branches, namely: a branch to the inner border of the little finger; a branch which divides to supply the contiguous borders of the ring and little fingers, and a branch which communicates with the radial and participates in the supply of the adjacent borders of the ring and middle fingers.

(*d*) The **superficial terminal branch** of the ulnar nerve gives off a branch to supply the palmaris brevis muscle, several twigs, which are distributed to the skin covering the hypothenar eminence, and then it divides into two branches, an inner and an outer. The **inner branch** is distributed to the inner side of the little finger on its volar aspect. The **outer branch** communicates with the median nerve, and then divides to supply the contiguous margins of the ring and little fingers. The distribution of these branches to the fingers resembles that of the digital branches of the median nerve, which has been already described.

(*e*) The **deep branch of the ulnar nerve** accompanies the deep branch of the ulnar artery into the interval between the abductor and flexor brevis minimi digiti muscles, and then passes through the fibres of the opponens minimi digiti to reach the deep surface of the flexor tendons. It supplies the abductor, flexor brevis, and opponens minimi digiti, the two inner lumbricales, all the interossei, the adductors, and the inner head of the flexor brevis pollicis. Occasionally it also gives a twig to the outer head of the flexor brevis pollicis.

(7) The **musculo-spiral nerve** is the largest branch of the brachial plexus. It arises from the posterior cord, and contains fibres derived from the fifth, sixth, seventh, and eighth cervical nerves. It is placed at first behind the third stage of the axillary artery; lower down it has a similar relation to the upper part of the brachial artery. It soon leaves the latter vessel and accompanies the superior profunda artery into the interval between the inner and outer heads of the triceps. Having followed the spiral groove around the humerus, it pierces the external inter-muscular septum and runs downwards in the interval between the supinator longus (brachio-radialis) and the brachialis anticus muscles. A little above the bend of the elbow it terminates by dividing into the radial and the posterior interosseous nerves.

Branches.—The musculo-spiral nerve gives off three cutaneous branches, one internal and two external, and supplies the following muscles: triceps, anconeus, brachialis anticus in part, supinator longus, and extensor carpi radialis longior.

(*a*) The **internal cutaneous branch** arises within the axilla, usually in common with the branch to the long head of the triceps. It crosses the tendon of the latissimus dorsi muscle and passes behind the intercosto-humeral nerve to the back of the arm, supplying a strip of integument in the middle of the dorsal surface extending nearly down to the elbow, and placed between the areas of distribution of the circumflex and intercosto-humeral nerves.

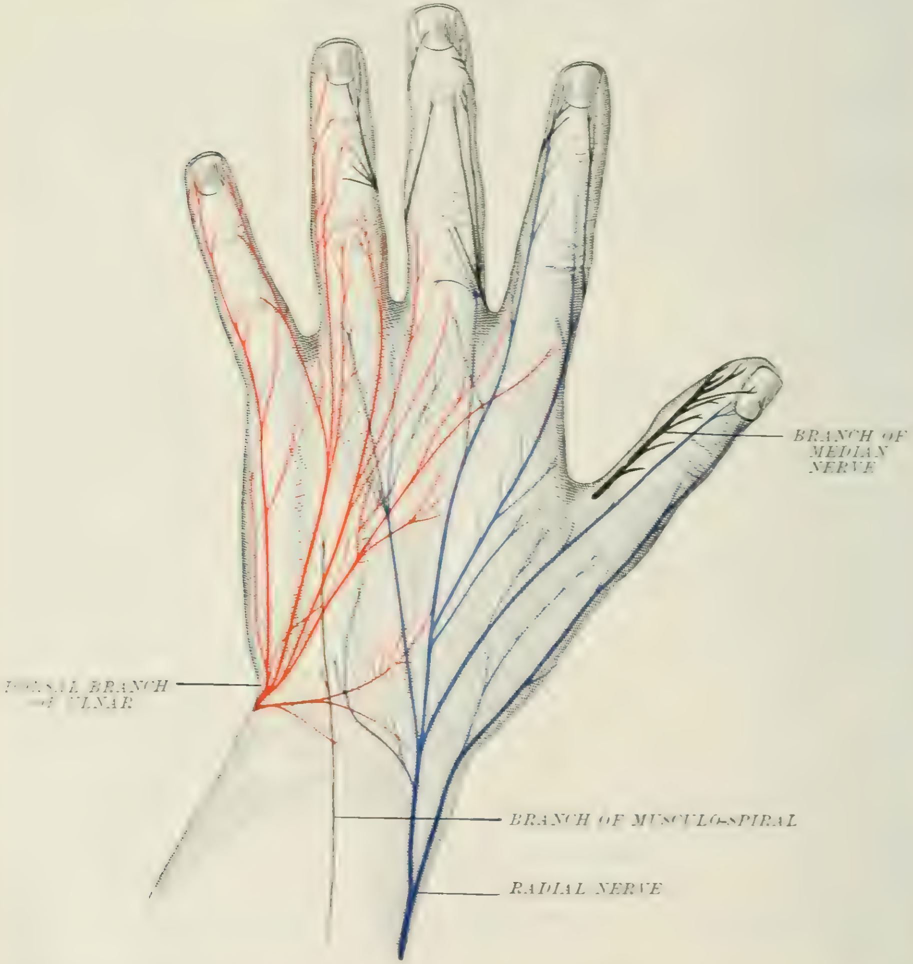
(*b*) The **external cutaneous branches** are distinguished as upper and lower. The **upper branch,** much the smaller, pierces the deep fascia in the line of the external intermuscular septum; it accompanies the lower part of the cephalic vein and supplies the skin over the lower half of the outer and anterior aspect of the arm. The **lower branch** is of considerable size. It pierces the deep fascia a little below the upper branch, runs behind the external condyle, and supplies the skin of the middle of the back of the forearm as far as the wrist, anastomosing with the internal cutaneous and musculo-cutaneous nerves.

(*c*) **Muscular Branches.**—Muscular branches are given off in the axilla to the long and internal heads of the triceps; one of the latter is a long filament which accompanies the ulnar nerve and is known as the ulnar collateral. At the back of the humerus muscular branches are given to the outer and inner heads of the triceps and to the anconeus; the latter descends in the substance of the inner head of the triceps accompanied by a branch of the superior profunda artery. At the outer side of the humerus branches are supplied to the supinator longus, the extensor carpi radialis longior, and to a section of the brachialis anticus; from one of these an articular twig is given off to the elbow-joint.

(*d*) The **posterior interosseous nerve** passes downwards in the interval between the brachialis anticus and the extensor carpi radialis longior, and, having given off branches to supply the extensor carpi radialis brevior and supinator brevis, it is crossed by the radial recurrent artery; then it runs downwards and backwards through the substance of the supinator brevis, and enters the cellular interval between the superficial and deep layers of muscles at the back of the forearm; here it comes into relation with the posterior interosseous artery, which it accompanies across the extensor ossis metacarpi pollicis. At the lower border of the latter muscle it gives off a branch to the extensor secundii internodii pollicis, and another which crosses the secundii internodii pollicis to reach the extensor indicis: then, leaving the posterior interosseous artery, it dips beneath the extensor secundii internodii pollicis and comes into relation with the anterior interosseous artery, which it accompanies upon the interosseous membrane and the back of the radius, passing through the groove for the extensor communis digitorum and the extensor indicis, to the back of the wrist, where it terminates in a gangliform enlargement, from which branches are given to the carpal articulations. The muscles supplied by the posterior interosseous nerve are the extensor carpi radialis brevior, the supinator brevis, the extensor communis digitorum, extensor minimi digiti, extensor carpi ulnaris, the three extensor muscles of the thumb, and the extensor indicis. The supinator brevis receives two twigs, one of which is given off before the nerve pierces the muscle, and the other while it is traversing the muscular substance.

Fig. 459.—A Dissection of the Cutaneous Nerves on the Dorsal Aspect of the Hand and Fingers. (H. St. J. B.)

The branches of the median nerve are shown in black.



(f) The **radial nerve** is somewhat smaller than the posterior interosseous, and is a purely cutaneous nerve. It runs downwards under cover of the supinator longus, crossing the radial recurrent artery and the supinator brevis; it approaches the radial artery at an acute angle, and runs parallel to the outer side of that vessel in the middle third of the forearm, crossing the pronator radii teres. It then parts company with the artery by bending backwards on the deep surface of the tendon of the supinator longus. It pierces the deep fascia in the lower third of the forearm and is directed towards the back of the wrist, where it divides into its terminal branches. One of these, the palmar cutaneous of the radial nerve, supplies the outer part of the thenar eminence; two others supply the dorsum of the thumb, a fourth branch runs along the radial side of the index finger, a fifth divides to supply the adjacent side of the index and middle fingers, and a sixth branch communicates with the dorsal branch of the ulnar nerve to supply the adjacent side of the middle and ring fingers.

Nerve-supply of the dorsal integument to the hand.—It will be seen, by the foregoing description of the radial and ulnar nerves, that the thumb, index, and half the middle finger are supplied by the radial; the little and half the ring finger by the ulnar; and the adjacent sides of the ring and middle fingers by both radial and ulnar nerves. The distance to which these nerves extend on the digits is somewhat variable, but the following is the average condition:—The radial nerve extends to the base of the thumb nail, to the distal interphalangeal joint of the index, and not quite to the proximal interphalangeal joint of the middle finger, and sends a fine twig in some cases to the skin covering the metaphalangeal articulation of the ring finger. The ulnar nerve extends to the nail of the little finger, to the distal interphalangeal joint of the ring, and in some cases to the integument covering the proximal interphalangeal joint of the middle, and the metacarpo-phalangeal articulation of the index finger. The distal parts of the dorsum of the fingers are supplied by twigs from the palmar collateral branches of the median and ulnar nerves, almost the whole of the middle finger being supplied in this way, and the other digits to a less degree. The matrix of the thumb nail is supplied by twigs from the palmar branches of the median. A considerable part of the dorsum of the hand is usually supplied by twigs from both the radial and the ulnar nerves, as these nerves overlap one another in their distribution (fig. 459). Occasionally two other nerves, the musculo-cutaneous and the lower external cutaneous branch of the musculo-spiral, take part in the supply of the back of the hand.

Table Showing Relation of Cervical and Dorsal Nerves to Branches of Brachial Plexus

Nerve Roots.	Nerves.
5 C.	Nerve to rhomboids ,, subclavius
5 and 6 C.	Suprascapular Nerve to subclavius Upper subscapular Lower ,, Circumflex
5, 6, and 7 C.	Posterior thoracic External anterior thoracic Musculo-cutaneous
5, 6, 7, and 8 C.	Musculo-spiral
6, 7, 8 C., and 1 D.	Median
7 and 8 C.	Middle subscapular
8 C. and 1 D.	Internal anterior thoracic Ulnar Internal cutaneous
1 D.	Lesser internal cutaneous

TABLE SHOWING THE RELATIONS OF THE MUSCLES OF THE UPPER EXTREMITY TO THE CERVICAL NERVES

NERVE ROOTS.	MUSCLES.	NERVES.
11th cranial, 2 C.	Sterno-mastoid	Spinal accessory
,, 3, 4 C.	Trapezius	,, ,, 3 and 4 C.
3 and 4 C.	Levator anguli scapulæ	3 and 4 C.
5 and 6 C.	Subclavius	Nerve to subclavius
	Supraspinatus	Suprascapular
	Infraspinatus	
	Subscapularis	Upper and lower subscapular
	Teres major	Lower subscapular
	Teres minor	Circumflex
	Deltoid	
	Brachialis anticus	Musculo-cutaneous
	Biceps	
6 C.	Supinator longus	Musculo-spiral
	Supinator brevis	Posterior interosseous
	Pronator radii teres	Median
	Flexor carpi radialis	,,
	Palmaris longus	,,
6 and 7 C.	Ext. carpi radialis longior	Musculo-spiral
	,, ,, brevior	Posterior interosseous
	Abductor pollicis	Median
	Opponens ,,	,,
	Flexor brevis pollicis (superf. head)	,,
5, 6, and 7 C.	Serratus magnus	Posterior thoracic
7 C.	Coraco-brachialis	Musculo-cutaneous
	Ext. comm. digitorum	Posterior interosseous
	,, minimi digiti	,, ,,
	,, carpi ulnaris	,, ,,
	,, oss. metac. pollicis	,, ,,
	,, primi inter. ,,	,, ,,
	,, sec. ,, ,,	,, ,,
	,, indicis	,, ,,
7 and 8 C.	Latissimus dorsi	Long subscapular
	Triceps	Musculo-spiral
	Anconeus	,, ,,
5, 6, 7, and 8 C.	Pectoralis major	Ext. and int. ant. thoracic
8 C.	Dorsal inteross.	Ulnar
	Palmar ,,	,,
	Obliq. add. pollicis	,,
	Trans. ,, ,,	,,
	Flex. brev. ,, (deep)	,,
7, 8 C., and 1 D.	Pectoralis minor	Int. ant. thoracic
	Flex. subl. digit.	Median
	Lumbricals	,, and ulnar
8 C. and 1 D.	Flex. carpi ulnaris	Ulnar
	,, prof. digit.	,, and median
	,, long. pollicis	Median
	Pronator quadratus	,,

THORACIC NERVES

The smaller part of the first thoracic nerve and the second to the eleventh thoracic nerves follow the contour of the body wall in the intervals between the ribs, and are therefore termed **intercostal nerves.** The twelfth thoracic nerve pursues a parallel course to the others, below the twelfth rib. Each of the intercostal nerves is accompanied by an intercostal artery and vein. These vessels are placed, immediately above the nerve, in the groove at the lower border of the rib. The twelfth thoracic nerve is accompanied by the first lumbar artery. Each thoracic nerve is joined, near the head of the rib, by two **rami communicantes** from the gangliated cord of the sympathetic. The first and last thoracic nerves require separate description. The remaining ten nerves fall naturally into an upper and a lower group. The members of the **upper group** (the second to the sixth) run between the ribs as far as the margin of the sternum. The members of the **lower group** (seventh to eleventh nerves) lie for a part of their course between the layers of the abdominal wall, the extent of the abdominal distribution increasing from the highest to the lowest member of the series.

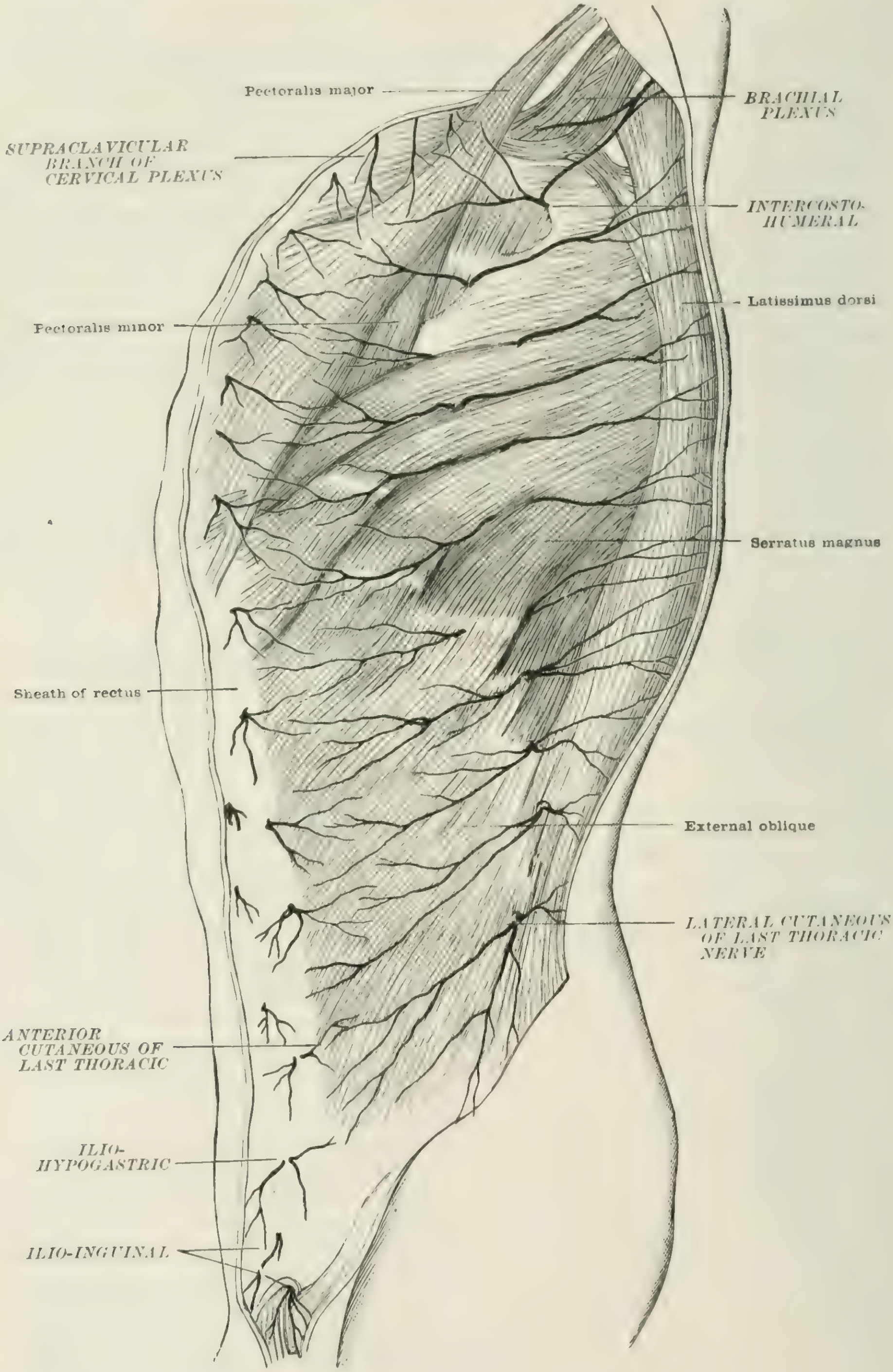
A. **First thoracic nerve.**—The greater part of the first thoracic nerve crosses the neck of the first rib to join the brachial plexus, as already described. The smaller part, about one-fifth of the entire nerve, runs for about two inches in contact with the under surface of the first rib between the bone and the pleura, and then enters the cellular interval between the external and internal intercostal muscles. For the remainder of its course it corresponds to the upper intercostal nerves in its distribution, but it does not usually give a lateral or an anterior cutaneous branch.

Variety.—In some cases a lateral cutaneous nerve arises from the first intercostal nerve. It may be of small size, but is sometimes as large as an ordinary intercosto-humeral nerve. It communicates with the intercosto-humeral nerve and with the nerve of Wrisberg.

B. **Upper intercostal nerves.**—The second, third, fourth, fifth, and sixth intercostal nerves, after receiving communications from the sympathetic, are directed outwards in the intercostal spaces in front of the posterior intercostal membrane, between that membrane and the pleura. They then enter the interval between the external and internal intercostal muscles, and follow the curve of the thoracic wall between these muscles as far as the mid-axillary line, and then, taking a deeper position, they run through the fibres of the internal intercostals as far as the junction of the bony parts of the ribs with their cartilages. Hence they pass forwards on the deep surface of the internal intercostal muscles, lying on the pleura and on the slips of the triangularis sterni, and cross in front of the internal mammary vessels. Lastly, they bend forwards and pierce the internal intercostals, the anterior intercostal membranes and the pectoralis major, and terminate as the anterior cutaneous nerves of the thorax. In this course they give off muscular branches to the levatores costarum, serratus posticus superior, external and internal intercostals, and triangularis sterni. Each nerve also gives off two cutaneous branches—namely, the lateral and anterior cutaneous nerves of the thorax.

The **lateral cutaneous nerves of the thorax** pierce the external intercostal muscles, and divide into anterior and posterior branches. These branches pass between the digitations of the serratus magnus, and are separated by an interval of about half an inch when they appear on the superficial surface of that muscle. The **anterior branches** run forwards, cross the lower border of the great pectoral, and supply the integuments which cover the lower and outer portion of that muscle, and give twigs to the mammary gland. They increase progressively in size from above downwards. In the case of the second lateral cutaneous nerve, the anterior branch is usually wanting. The **posterior branches** turn backwards, and supply the skin covering the outer part of the latissimus dorsi and the inferior angle of the scapula. The lateral cutaneous branches of the second and third intercostal nerves are larger than the others, and require separate notice. The lateral cuta-

FIG. 460.—CUTANEOUS NERVES OF THE THORAX AND ABDOMEN, VIEWED FROM THE SIDE. (After Henle.)


Pectoralis major
BRACHIAL PLEXUS
SUPRACLAVICULAR BRANCH OF CERVICAL PLEXUS
INTERCOSTO-HUMERAL
Latissimus dorsi
Pectoralis minor
Serratus magnus
Sheath of rectus
External oblique
LATERAL CUTANEOUS OF LAST THORACIC NERVE
ANTERIOR CUTANEOUS OF LAST THORACIC
ILIO-HYPOGASTRIC
ILIO-INGUINAL

neous branch of the second intercostal nerve is called the **intercosto-humeral nerve.** It passes outwards across the axillary space, crosses the tendon of the latissimus dorsi and the internal cutaneous branch of the musculo-spiral nerve to reach the arm. It is distributed to the integument of the inner and posterior part of the arm in its upper two-thirds. Within the axilla it communicates with the lesser internal cutaneous nerve of the brachial plexus, and with the lateral cutaneous branch of the third intercostal. The **lateral cutaneous branch** of the **third intercostal** divides into a small anterior and a large posterior branch. The anterior branch ends near the margin of the great pectoral muscle. The posterior branch communicates with the intercosto-humeral nerve, and then turns round the posterior fold of the axilla, and, after giving a twig to the integument of the arm, ends in the skin covering the dorsum of the scapula.

The **anterior cutaneous nerves of the thorax** are the terminal branches of the upper intercostal nerves. They pierce the pectoralis major in company with the perforating branches of the internal mammary artery. On reaching the surface of the muscle, they give off minute twigs, which supply the skin over the sternum, and then end in slender branches which are directed outwards to supply the skin covering the greater part of the pectoralis major. Some twigs from the third, fourth, fifth, and sixth nerves are distributed to the mammary gland.

C. **Lower intercostal nerves.**—The seventh, eighth, ninth, tenth, and eleventh intercostal nerves, in the part of their course which lies between the ribs, present the same relations as the upper intercostal nerves. Leaving the intercostal spaces they pass behind, or in the last two spaces between the costal cartilages, and then forwards between the internal oblique and transversalis muscles, where they anastomose together, in a plexiform manner. Piercing the posterior lamella of the internal oblique aponeurosis, they enter the sheath of the rectus abdominis; they supply the rectus muscle, pass through it, pierce the anterior part of its sheath and terminate as the anterior cutaneous nerves in the skin of the abdomen.

Branches.—The lower intercostal nerves supply the external and internal intercostal muscles, the levatores costarum, the serratus posticus inferior, the internal oblique, the transversalis, the rectus, and from one or more of them twigs are given to the costal fibres of the diaphragm. They also give off lateral cutaneous branches, by which the external oblique is supplied.

The **lateral cutaneous nerves of the abdomen** are the continuation of the series of the lateral cutaneous nerves of the thorax. They divide into anterior and posterior branches, which pierce the external oblique. The **anterior branches** are directed forwards and somewhat downwards, and supply the integument covering the anterior abdominal wall as far as the outer margin of the rectus. Each nerve gives off a muscular twig, which pierces the adjacent digitation of the external oblique muscle on its superficial surface. The **posterior branches** pass backwards around the margin of the latissimus dorsi, and end in the skin of the outer part of the back.

The **anterior cutaneous nerves of the abdomen** are the terminal branches of the lower intercostal nerves, and pierce the anterior part of the sheath of the rectus to supply the skin covering that muscle. These nerves are of small size, and sometimes divide before their emergence, so as to form a double series.

D. **Last thoracic nerve.**—This nerve gives off a communicating twig to the first lumbar nerve, and then passes beneath the external arcuate ligament, and runs outwards below the twelfth rib across the front of the quadratus lumborum, accompanied by the first lumbar artery. It pierces the posterior aponeurosis of the transversalis, and follows the curve of the abdominal wall between the transversalis and internal oblique muscles. In the remainder of its course it resembles a lower intercostal nerve. After piercing the rectus, however, it supplies the pyramidalis (Griffin). Its lateral cutaneous branch remains undivided, and represents the anterior division of an ordinary lateral cutaneous branch. On account of its distribution, it is named the iliac branch. The **iliac branch** pierces the external oblique about three inches above the iliac crest, and is directed downwards, across the crest, a short distance behind the anterior superior spine. It ends in the integument covering the anterior part of the gluteal region.

LUMBAR NERVES

The anterior divisions of the five lumbar nerves increase progressively in size from above downwards, the first lumbar being about the size of an intercostal nerve, and the fifth a nerve of considerable magnitude. The first, second, third, and part of the fourth nerves unite to form the lumbar plexus. The remainder of the fourth unites with the fifth to form the lumbo-sacral cord, which passes to the sacral plexus. Each lumbar nerve is connected to the gangliated cord of the sympathetic by rami communicantes. These rami communicantes reach the lumbar nerves by accompanying the lumbar arteries through the fibrous arches from which the psoas takes origin.

LUMBAR PLEXUS

The **lumbar plexus** is placed among the deeper fibres of the psoas, and is constituted as follows: the first lumbar nerve is joined by a communicating twig from the twelfth thoracic and divides into two branches; one of these is the common origin of the ilio-hypogastric and ilio-inguinal nerves; the other branch unites with a branch of the second lumbar to form the genito-crural nerve. The second, third, and fourth lumbar nerves divide into anterior and posterior divisions. A part of the anterior division of the second lumbar nerve enters into the composition of the genito-crural nerve as above mentioned; the remainder of the anterior division of the second nerve unites with the anterior division of the third and part of the fourth nerve to form the obturator nerve. The remainder of the anterior division of the fourth nerve enters the lumbo-sacral cord. The fourth lumbar nerve, therefore, takes part in the formation of both the lumbar and sacral plexuses; and it is known as the "nervus furcalis." The posterior divisions of the second, third, and fourth nerves end chiefly in two large nerves—the external cutaneous and the anterior crural. The external cutaneous arises from the second and third nerves. The anterior crural springs from the second, third, and fourth nerves. A part of the posterior division of the fourth nerve enters the lumbo-sacral cord. The large terminal branches above described are given off within the substance of the psoas: three of these, the ilio-hypogastric, ilio-inguinal, and external cutaneous, appear at the outer border of the psoas, between that muscle and the quadratus lumborum: one, the genito-crural, pierces the anterior fibres of the psoas and appears in front of the muscle; another branch, the obturator, appears at the inner border of the psoas close to the lower margin of the fifth lumbar vertebra; lastly, the anterior crural nerve, the largest branch of the plexus, runs downwards in the interval between the psoas and iliacus. Within the psoas small twigs are given off by the lumbar nerves, which end in the muscular substance of the psoas and quadratus lumborum.

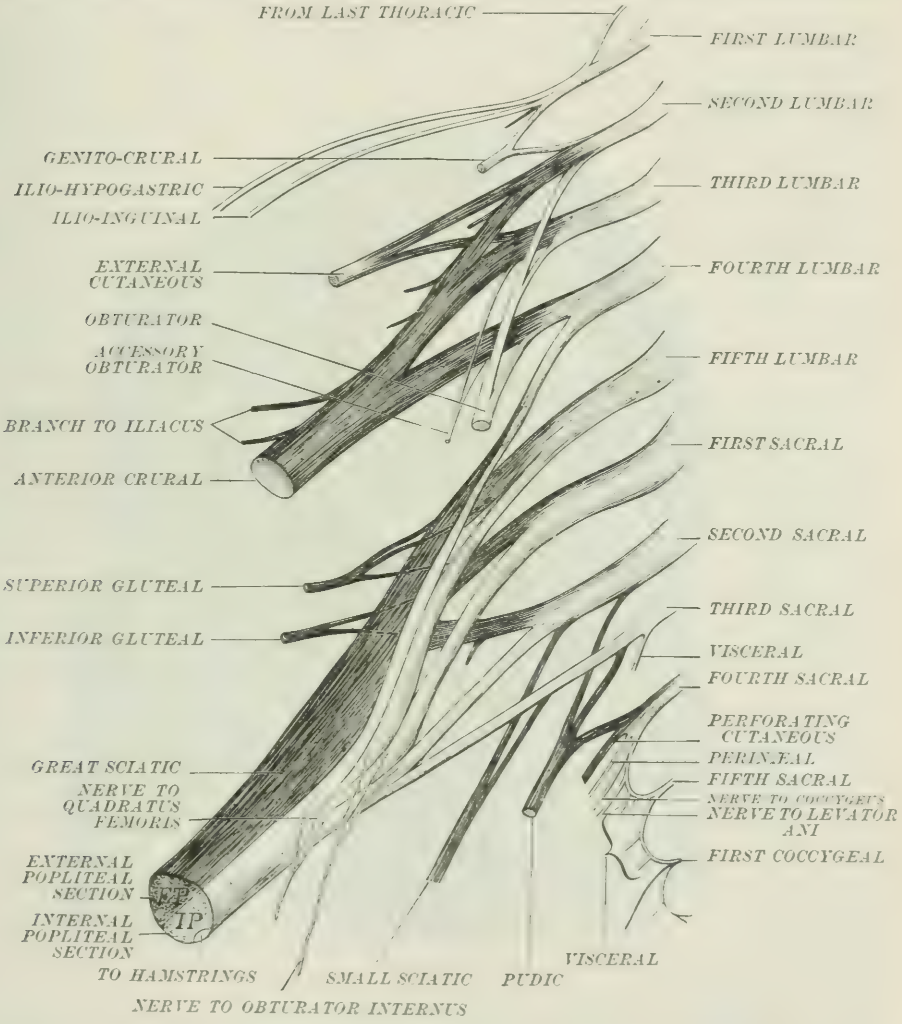
Branches.—The nerves to the *psoas* and *quadratus lumborum* from the first and second lumbar nerves arise in the substance of the psoas.

The ilio-hypogastric and ilio-inguinal nerves are in some cases represented by a common trunk which arises from the first lumbar. More commonly they exist as two separate nerves, the upper and larger nerve being ilio-hypogastric: the lower and smaller, ilio-inguinal. Taken together they correspond in many respects to a lower intercostal nerve. They run for a considerable part of their course between the transversalis and internal oblique, giving twigs to both these muscles. The ilio-hypogastric gives off a lateral cutaneous, which is called the **iliac branch,** and terminates in an anterior cutaneous which is termed the **hypogastric branch.**

(1) The **ilio-hypogastric nerve** is a branch of the first lumbar. It appears at the outer border of the psoas and crosses the quadratus lumborum obliquely to reach the crest of the ilium. In this part of its course it is surrounded by the extra-peritoneal fat. It then pierces the transversalis and runs along the crest of the ilium between that muscle and the internal oblique, and, about two and a half inches behind the anterior superior spine of the ilium, divides into an iliac and

an hypogastric branch. *(a)* The **iliac branch** pierces the internal and external oblique muscles and crosses the crest of the ilium, lying close to the bone. It is directed downwards towards the great trochanter of the femur; some of its twigs reach as far as that prominence, and supply the integuments covering the fore part of the gluteal region. *(b)* The **hypogastric branch** continues the direction of the main trunk, and perforates the internal oblique near the anterior superior spine of the ilium. In this part of its course it communicates in a plexiform manner with the ilio-inguinal nerve. It is then directed forwards and inwards under cover of the aponeurosis of the external oblique. Finally it pierces the aponeurosis outside the sheath of the rectus at a point about an inch above the external abdominal ring, and supplies the skin in that situation, forming a continuation of the series of anterior cutaneous nerves of the abdomen.

Fig. 461.—Diagram of the Lumbar and Sacral Plexuses. (Modified from Paterson.)

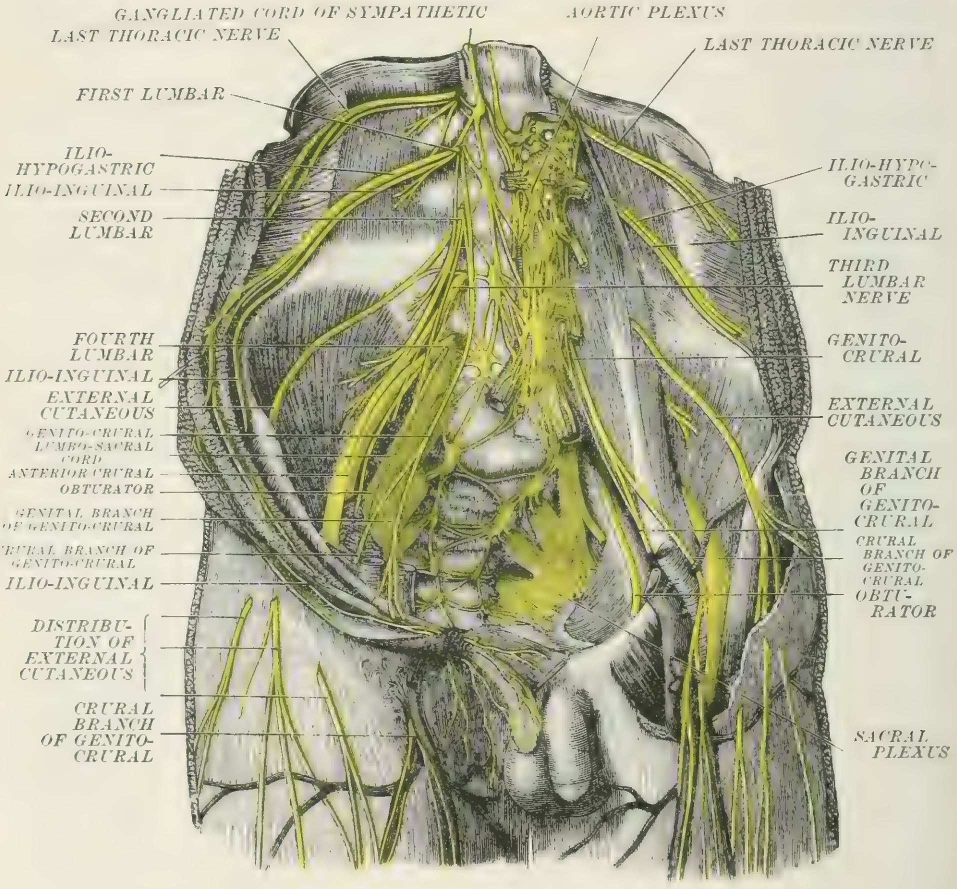

FROM LAST THORACIC
FIRST LUMBAR
SECOND LUMBAR
GENITO-CRURAL
ILIO-HYPOGASTRIC
ILIO-INGUINAL
THIRD LUMBAR
EXTERNAL CUTANEOUS
FOURTH LUMBAR
OBTURATOR
ACCESSORY OBTURATOR
FIFTH LUMBAR
BRANCH TO ILIACUS
FIRST SACRAL
ANTERIOR CRURAL
SECOND SACRAL
SUPERIOR GLUTEAL
THIRD SACRAL
INFERIOR GLUTEAL
VISCERAL
FOURTH SACRAL
PERFORATING CUTANEOUS
PERINEAL
GREAT SCIATIC
FIFTH SACRAL
NERVE TO COCCYGEUS
NERVE TO QUADRATUS FEMORIS
NERVE TO LEVATOR ANI
FIRST COCCYGEAL
EXTERNAL POPLITEAL SECTION
EP
INTERNAL POPLITEAL SECTION
IP
VISCERAL
TO HAMSTRINGS
SMALL SCIATIC
PUDIC
NERVE TO OBTURATOR INTERNUS

(2) The **ilio-inguinal nerve** arises from the first lumbar nerve in common with the ilio-hypogastric, and accompanies the last-named nerve across the quadratus lumborum, but at a lower level. It then passes obliquely across the upper part of the iliacus and pierces the transversalis muscle. It follows the curve of the crest of the ilium in company with the ilio-hypogastric, communicating with that

nerve in a plexiform manner. It pierces the internal oblique a little in front of the anterior superior spine of the ilium, and runs forwards under cover of the aponeurosis of the external oblique immediately above Poupart's ligament, enters the lower part of the inguinal canal and reaches the external abdominal ring. It then traverses the ring and divides into its terminal branches, which are distributed to the skin covering the upper part of the adductor longus, the integuments of the scrotum in the male, and of the labium majus in the female.

(3) The **genito-crural nerve** arises from the first and second lumbar nerve by two roots which pass forwards and downwards through the fibres of the psoas, and unite to form a single trunk. The nerve then appears on the surface of the psoas close to the vertebral column, at the level of the third lumbar vertebra and runs downwards under cover of the peritoneum. After being crossed by the ureter it reaches the outer side of the external iliac artery, where it divides into a genital and a crural branch.

Fig. 462.—Branches of the Lumbar and Sacral Plexus viewed from before. (After Hirschfeld and Leveillé.)


GANGLIATED CORD OF SYMPATHETIC
AORTIC PLEXUS
LAST THORACIC NERVE
LAST THORACIC NERVE
FIRST LUMBAR
ILIO-HYPOGASTRIC
ILIO-INGUINAL
SECOND LUMBAR
ILIO-HYPOGASTRIC
ILIO-INGUINAL
THIRD LUMBAR NERVE
FOURTH LUMBAR
ILIO-INGUINAL
GENITO-CRURAL
EXTERNAL CUTANEOUS
EXTERNAL CUTANEOUS
GENITO-CRURAL
LUMBO-SACRAL CORD
ANTERIOR CRURAL
GENITAL BRANCH OF GENITO-CRURAL
OBTURATOR
GENITAL BRANCH OF GENITO-CRURAL
CRURAL BRANCH OF GENITO-CRURAL
CRURAL BRANCH OF GENITO-CRURAL
ILIO-INGUINAL
OBTURATOR
DISTRIBUTION OF EXTERNAL CUTANEOUS
CRURAL BRANCH OF GENITO-CRURAL
SACRAL PLEXUS

(*a*) The **genital branch** accompanies the spermatic vessels through the inguinal canal, and, emerging from the external abdominal ring, pierces the internal spermatic fascia, and is distributed to the cremaster muscle. In the female this branch is rudimentary and accompanies the round ligament.

(*b*) The **crural branch** is carried downwards in front of the external iliac and femoral artery into the external compartment of the femoral sheath. It pierces the femoral sheath and becomes subcutaneous about two inches below Poupart's ligament by piercing the fascia lata. It is distributed to the skin covering the upper and central part of the anterior aspect of the thigh.

(4) The **obturator nerve** arises from the third and fourth lumbar nerves, and in the majority of cases receives an additional root from the second. It passes between the psoas muscle and the body of the fifth lumbar vertebra. It then runs downwards and forwards outside the internal iliac vessels and the ureter, and below the external iliac vessels to reach the upper margin of the thyroid foramen. In this part of its course it runs parallel to and a little below the brim of the pelvis, and is placed in the extra-peritoneal fat between the peritoneum and the parietal pelvic fascia. It is accompanied by the obturator vessels which are placed below it. The nerve then passes through the deficiency in the obturator membrane, and divides into two branches, an anterior and a posterior.

(*a*) The **anterior branch** passes across the upper border of the obturator externus, and is directed downwards and inwards between the pectineus and adductor brevis, and divides into the following branches:—(i) A twig for the hip-joint; (ii) a branch for the adductor longus; (iii) a branch to supply the adductor brevis; (iv) a branch for the gracilis; (v) in rare cases, a twig for the pectineus; (vi) a cutaneous branch; and (vii) a branch to the femoral artery. The cutaneous branch becomes superficial by passing between the adductor longus and adductor brevis, and is then directed along the posterior border of the sartorius, where it communicates with twigs from the long saphenous and from the posterior branch of the internal cutaneous to form the subsartorial plexus.

(*b*) The **posterior branch** gives off branches to supply the hip-joint and the obturator externus, and then pierces the upper part of that muscle and reaches the interval between the adductor brevis and adductor magnus. It runs downwards on the anterior surface of the latter muscle, supplying it with twigs, and terminates in an articular twig, the geniculate branch, which is distributed to the knee-joint. (i) The twig to the hip-joint enters the acetabulum by passing through the cotyloid notch. It ramifies in the fat occupying the floor of the acetabulum and in the adjacent synovial membrane. (ii) The branch to the obturator externus pierces the deep surface of the muscle. (iii) Several large twigs enter the adductor magnus. (iv) The geniculate branch pierces the lower part of the adductor magnus and appears on the posterior surface of that muscle close to the opening for the popliteal vessels, and descends on the inner side of (sometimes behind) the popliteal artery. Having given off a filament which accompanies the superior internal articular artery, it breaks up into terminal twigs which separately pierce the posterior ligament of the knee-joint.

An **accessory obturator nerve** is occasionally present. It arises between the anterior crural and obturator nerves from the third and fourth lumbar nerves. It runs along the inner border of the psoas, and crosses in front of the brim of the pelvis to gain the deep surface of the pectineus. In this situation it breaks up into branches. The largest of these branches joins the obturator nerve, others enter the capsule of the hip-joint, and a branch is furnished to the pectineus.

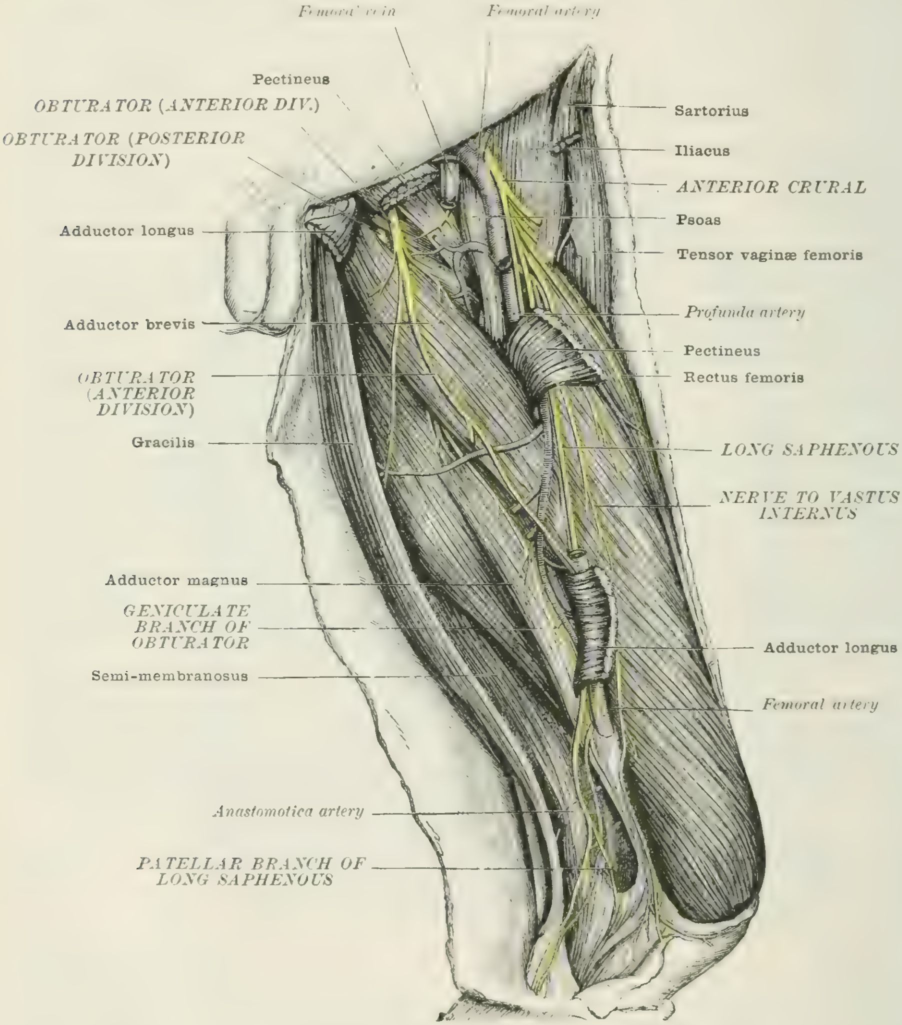
The branch which joins the obturator nerve may carry filaments for the adductors longus and brevis, and the gracilis.

(5) The **external cutaneous nerve** arises, by two roots, from the second and third lumbar nerves. It emerges at the outer border of the psoas, and crosses obliquely in front of the iliacus to reach the interval between the anterior superior and anterior inferior spines of the ilium. In this course it runs under cover of the fascia iliaca. It then passes behind Poupart's ligament, crosses in front of the origin of the sartorius, and divides into an anterior and a posterior branch. The **posterior branch** passes backwards and downwards under cover of the fascia lata, and divides into twigs which supply the integument covering the insertion of the gluteus maximus and the upper and outer part of the thigh. The **anterior branch** is much larger than the posterior. It runs downwards for several inches in a canal formed by the fascia lata, and enters the superficial fascia at the junction of the upper with the middle third of the thigh. It divides into branches which supply the skin of the outer part of the thigh, a few of the terminal twigs reaching as far as the knee and entering into the composition of the plexus patellæ.

(6) The **anterior crural nerve** is the largest branch of the lumbar plexus. It arises by three roots, which spring from the second, third, and fourth lumbar nerves; these roots traverse the substance of the psoas and unite into a single trunk in the deep groove between the psoas and iliacus muscles. The nerve then passes under cover of the fascia iliaca, behind Poupart's ligament, into Scarpa's triangle, where it lies external to the femoral sheath and divides into two groups of terminal branches—the superficial and deep.

In the abdominal part of its course the anterior crural nerve gives branches to the iliacus, and a twig to the femoral artery.

FIG. 463.—ANTERIOR CRURAL AND OBTURATOR NERVES. (Ellis.)


Femoral vein
Femoral artery
Pectineus
OBTURATOR (ANTERIOR DIV.)
OBTURATOR (POSTERIOR DIVISION)
Adductor longus
Adductor brevis
OBTURATOR (ANTERIOR DIVISION)
Gracilis
Adductor magnus
GENICULATE BRANCH OF OBTURATOR
Semi-membranosus
Anastomotica artery
PATELLAR BRANCH OF LONG SAPHENOUS
Sartorius
Iliacus
ANTERIOR CRURAL
Psoas
Tensor vaginæ femoris
Profunda artery
Pectineus
Rectus femoris
LONG SAPHENOUS
NERVE TO VASTUS INTERNUS
Adductor longus
Femoral artery

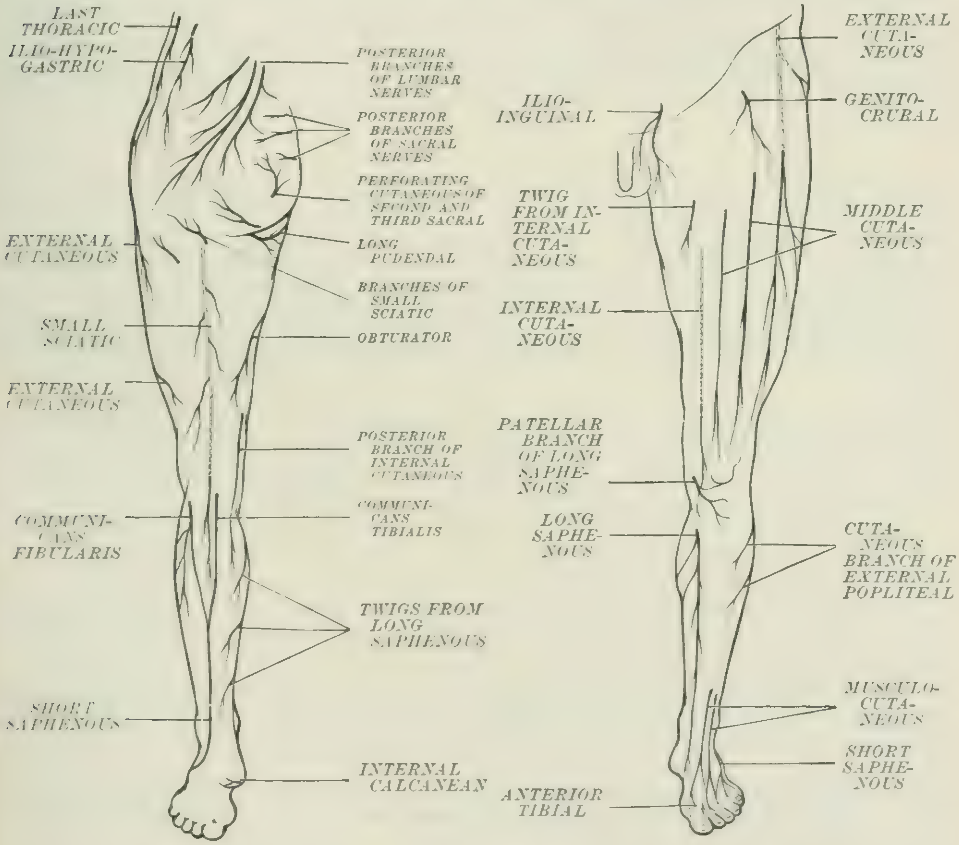
The **superficial terminal branches** are muscular and cutaneous; they are separated from the deep branches by the external circumflex artery.

The **muscular branches** of the superficial series contain fibres from the second and third lumbar nerves; they are two in number—one to the pectineus, which passes behind the femoral sheath to the anterior surface of the pectineus muscle, and one to the sartorius. The latter usually accompanies one of the two divisions of the middle cutaneous nerve.

The **cutaneous branches** of the superficial series are the internal and middle cutaneous nerves. They also contain fibres from the second and third lumbar nerves.

The **internal cutaneous nerve** is directed downwards along the outer side of the femoral artery, giving off in this situation two or three cutaneous twigs, which pierce the fascia lata. It then crosses obliquely in front of the femoral artery, at the lower angle of Scarpa's triangle, and divides into an anterior and a posterior branch. The **anterior branch** is the larger. It runs downwards, in front of the sartorius, under cover of the fascia lata. It pierces the fascia lata about the middle of the lower third of the thigh, and, after giving twigs to the skin of that region, turns outwards to end in the plexus patellæ. The **posterior branch** runs along the posterior border of the sartorius, and, after giving twigs to the subsartorial plexus, runs downwards to the inner aspect of the knee, where it pierces the deep fascia and ends in the integument of the upper and inner part of the calf.

FIG. 464.—DISTRIBUTION OF CUTANEOUS NERVES ON THE POSTERIOR AND ANTERIOR ASPECTS OF THE INFERIOR EXTREMITY.


LAST THORACIC
ILIO-HYPO-GASTRIC
EXTERNAL CUTANEOUS
SMALL SCIATIC
EXTERNAL CUTANEOUS
COMMUNICANS FIBULARIS
SHORT SAPHENOUS
POSTERIOR BRANCHES OF LUMBAR NERVES
POSTERIOR BRANCHES OF SACRAL NERVES
PERFORATING CUTANEOUS OF SECOND AND THIRD SACRAL
LONG PUDENDAL
BRANCHES OF SMALL SCIATIC
OBTURATOR
POSTERIOR BRANCH OF INTERNAL CUTANEOUS
COMMUNICANS TIBIALIS
TWIGS FROM LONG SAPHENOUS
INTERNAL CALCANEAN
ILIO-INGUINAL
TWIG FROM INTERNAL CUTANEOUS
INTERNAL CUTANEOUS
PATELLAR BRANCH OF LONG SAPHENOUS
LONG SAPHENOUS
ANTERIOR TIBIAL
EXTERNAL CUTANEOUS
GENITO-CRURAL
MIDDLE CUTANEOUS
CUTANEOUS BRANCH OF EXTERNAL POPLITEAL
MUSCULO-CUTANEOUS
SHORT SAPHENOUS

The **middle cutaneous nerve** usually takes the form of two strong branches, which run a nearly parallel course. One of these branches usually pierces the sartorius, while the other crosses the superficial surface of that muscle; they pierce the fascia lata a little above the middle of the thigh. They ramify in the superficial fascia, supplying the skin of the anterior part of the thigh as far as the knee, where they end in the plexus patellæ.

The **deep branches** are six in number—one cutaneous (the long saphenous) and five muscular. They are arranged in the following order, from within outwards: the long saphenous nerve, the nerve to the vastus internus, the nerve to the subcrureus, the nerve to the crureus, the nerve to the vastus externus, and the nerve to the rectus femoris. They all contain fibres from the third and fourth lumbar nerves.

(*g*) The **long** or **internal saphenous nerve** accompanies the nerve to the vastus internus in its course through Scarpa's triangle, being placed between the latter nerve and the femoral artery. It passes through Hunter's canal with the femoral artery, lying first to the outer side, then in front, and finally to the inner side of that vessel. At the lower end of the canal it joins the superficial branch of the anastomotic artery which it accompanies, between the posterior border of the sartorius muscle and the anterior border of the gracilis tendon, to the inner side of the knee where it becomes superficial. At this point it approaches the long saphenous vein, and accompanies that vessel for the remainder of its course. It runs down the anterior and inner part of the leg, supplying branches to the skin of that region, passes in front of the inner malleolus, and supplies the integument for about two inches below that prominence.

As it leaves Hunter's canal, the long saphenous nerve gives off a **patellar branch.** This branch pierces the sartorius, and runs, at first downwards and then outwards, towards the ligamentum patellæ. It gives twigs to the integument covering that ligament, and others which curve upwards to join the plexus patellæ.

Plexus patellæ.—The skin covering the patella is profusely supplied with nerves which communicate with one another, and are derived from the external, middle, and internal cutaneous and from the long saphenous.

Subsartorial plexus.—At the posterior border and partly under cover of the sartorius muscle, on the roof of Hunter's canal, and a little below the middle of the thigh, branches of the obturator, long saphenous, and internal cutaneous nerves communicate in a plexiform manner and supply the adjacent skin. The posterior branch of the internal cutaneous has an independent distribution, as already described. Occasionally the cutaneous branch of the obturator is unusually large, and may supply an area of integument covering the lower part of the inner hamstring muscles.

The **nerve to the vastus internus** accompanies the long saphenous nerve, in Scarpa's triangle, lying to its outer side. At the upper end of Hunter's canal it passes beneath the sartorius, external to the roof of the canal, and enters the inner surface of the vastus internus. It sends down a twig to the knee-joint.

The **nerve to the subcrureus** frequently rises from the nerve to the crureus. It passes between the vastus internus and the crureus to the lower third of the thigh, where it supplies the subcrureus and sends a branch to the knee-joint.

The **nerve to the crureus** is represented by two or three branches which enter the upper part of the muscle. One of them frequently sends a twig to the knee-joint.

The **nerve to the vastus externus** passes downwards beneath the rectus and along the anterior border of the vastus externus, accompanied by the descending branch of the external circumflex artery. It also sends a branch to the knee-joint.

The **nerve to the rectus femoris** enters the deep surface of that muscle, having previously given off a twig to the hip-joint which accompanies the ascending branch of the external circumflex artery.

SACRAL AND COCCYGEAL NERVES

The anterior primary divisions of the upper four sacral nerves escape from the neural canal by passing through the anterior sacral foramina, while the anterior division of the fifth passes forwards between the sacrum and coccyx. The coccygeal nerve escapes from the neural canal by passing through the terminal opening. Its anterior primary division pierces the sacro-sciatic ligaments and passes forwards. The sacral nerves decrease progressively in size, from the first to the fifth. The first sacral nerve is the largest nerve in the body, while the fifth is very small. Each sacral nerve is connected to the gangliated cord of the sympathetic by a gray ramus communicans. The anterior divisions of the first, second, third, and part of the fourth nerves join the sacral plexus; another part of the fourth has an independent distribution. The lower part of the fourth joins the fifth sacral and the coccygeal nerve to form the coccygeal plexus.

The branches of the fourth sacral nerve and the coccygeal plexus may be conveniently described first, as their distribution is confined to a limited area in the immediate neighbourhood of the sacral plexus.

FOURTH SACRAL NERVE

The **fourth sacral nerve,** called the "nervus bigeminus," gives off an ascending branch to join the sacral plexus, and a descending twig to the coccygeal plexus. In the interval between these communicating branches several offsets arise directly from the fourth sacral without entering into a plexiform arrangement. These direct offsets are the perinæal branch, and the muscular nerves to the coccygeus and to the levator ani.

The **perinæal branch** of the fourth sacral pierces the pelvic diaphragm, between the contiguous margins of the coccygeus and levator ani, and appears close to the tip of the coccyx. It is then directed forwards, and ends in twigs to the external sphincter ani and to the integument of the anus.

The **branches to the coccygeus** and **levator ani** enter these muscles on their deep or pelvic surfaces.

SACRO-COCCYGEAL PLEXUS

The anterior primary division of the fifth sacral nerve divides into ascending and descending branches. The ascending branch unites with the descending branch of the fourth sacral. The descending branch joins the coccygeal nerve. In this manner two small loops are formed; these loops constitute the sacro-coccygeal plexus. Anterior and posterior branches are given off by the plexus. The **anterior branches** join the hypogastric plexus (Testut). The **posterior branches** pierce the coccygeus muscle, and are distributed to the skin covering the posterior surface of the coccyx. The **coccygeal nerve** gives a twig to the coccygeus and (according to Testut) gives off a branch which pierces the great sacro-sciatic ligament and ends in the lower fibres of the gluteus maximus. The plexus is placed in front of the lower part of the sacrum and behind the second part of the rectum.

SACRAL PLEXUS

The **sacral plexus,** with the exception of the roots of the lumbo-sacral cord, is situated in the pelvis, behind the parietal pelvic fascia. It lies, for the most part, on the pyriformis, the fibres of that muscle often interlacing with the roots of the plexus.

It is behind the branches of the internal iliac vessels, two of which, the gluteal and sciatic, pass through its loops. On the left side it is also behind the first part of the rectum, and on the right the lower end of the ileum passes in front of it.

It is formed as follows: a part of the fourth lumbar nerve, "nervus furcalis," joins the fifth lumbar nerve to form the lumbo-sacral cord; this cord is then joined by the first, second, and third sacral nerves to form a great flattened band, which is directed outwards and downwards towards the lower margin of the great sacro-sciatic foramen, and, on crossing that margin, is no longer called the sacral plexus, but takes the name of the **great sciatic nerve.** A part of the third sacral nerve is joined by branches from the second and fourth sacral nerves to form a second or lower band of relatively small size, which ends in the **pudic nerve.** Several branches, to be presently enumerated, spring from the plexus; but by far the larger part of the plexus is directly continued into the great sciatic and pudic nerves. The plexus is, therefore, more condensed and more simple in its formation than any other plexus in the body. The two constituents of the lumbo-sacral cord unite to form that structure on, or a little below, the brim of the pelvis. The plexus has the following important vascular relations: the internal iliac vessels are placed a little in front of its upper part; the gluteal artery passes between the lumbo-sacral cord and the first sacral nerve; the sciatic artery passes through the lower part of the plexus (fig. 466).

It has been shown (Paterson) that the anterior primary divisions of the lower four lumbar and the upper two sacral nerves divide into anterior and posterior parts. The branches derived from the anterior parts (lightly shaded in fig. 465) always cross in front of the posterior parts and unite to form trunks (e.g. obturator, internal popliteal), which are distributed to what is morphologically the anterior aspect of the limb. The trunks which are formed from the posterior parts (e.g. external cutaneous, anterior crural, external popliteal) are distributed to the (morphologically) posterior aspect of the limb; these nerves are darkly shaded in fig. 465.

The branches of the sacral plexus are classified into collateral and terminal. The **collateral branches** are the superior gluteal, the inferior gluteal, the nerve to the pyriformis, visceral branches, the nerve to the quadratus, the small sciatic, the nerve to the obturator internus, and the perforating cutaneous nerve. The **terminal branches** are the great sciatic and the pudic nerves.

COLLATERAL BRANCHES.—1. The **superior gluteal nerve** arises by two roots, one from the lumbo-sacral cord, and the other from the first sacral nerve. The upper root contains fibres derived from the fourth and fifth lumbar nerves. The nerve accompanies the gluteal vessels through the great sacro-sciatic foramen, passing above the pyriformis. It then divides into a smaller upper and a larger lower branch. The upper branch accompanies the upper division of the deep part of the gluteal artery and terminates in the gluteus medius; the lower branch crosses the gluteus minimus with the lower branch of the deep part of the gluteal artery, supplying filaments to the gluteus medius and minimus and a terminal branch, which passes between their anterior borders, or through the fibres of the minimus, to the tensor fascia femoris.

2. The **inferior gluteal nerve** arises from the posterior aspect of the plexus, and contains fibres derived from the fifth lumbar and the first, second, and third sacral nerves. It escapes through the great sacro-sciatic foramen, below the pyriformis, and in this situation is often adherent to the small sciatic nerve. It divides into several stout twigs, which enter the deep surface of the gluteus maximus.

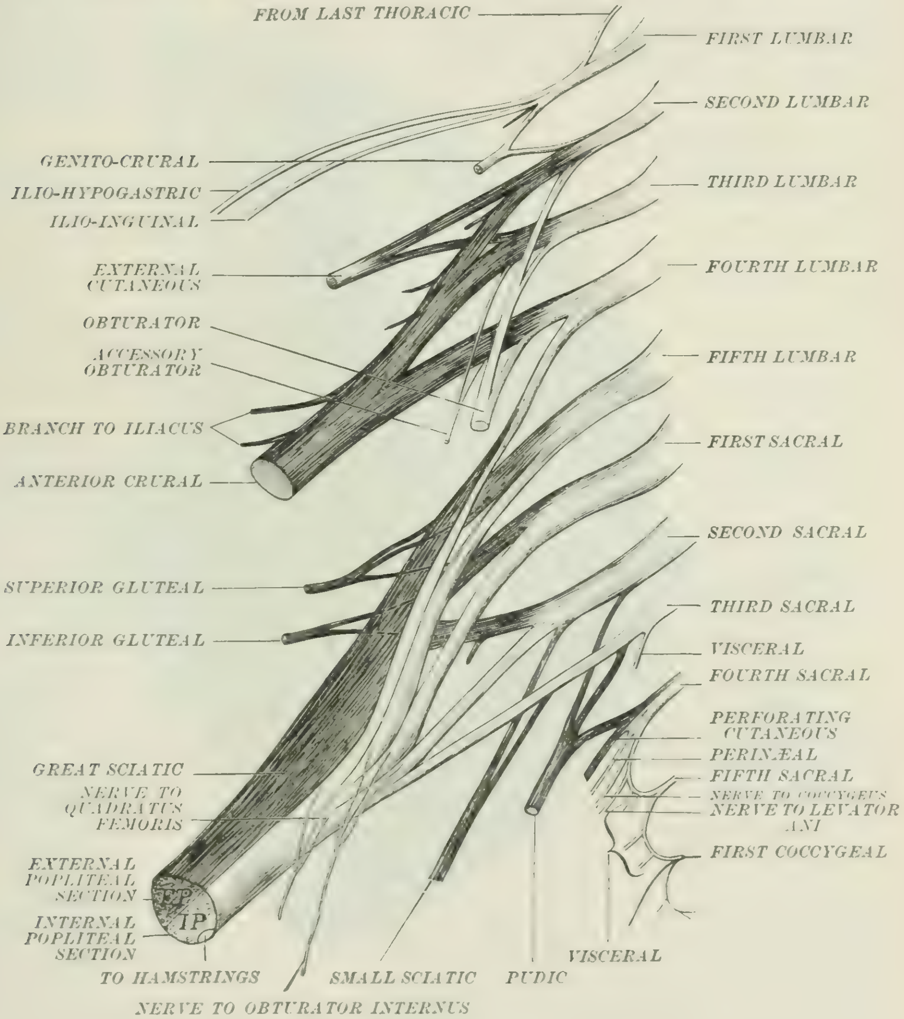
3. The **nerve to the pyriformis** is given off either from the second or from the third sacral nerve before they join the plexus.

4. The **visceral branches** arise from the third and fourth sacral nerves. They will be described in connection with the sympathetic.

5. The **nerve to the quadratus femoris** rises from the front of the plexus, obtaining fibres from the fourth and fifth lumbar and first sacral nerves. It passes through the great sacro-sciatic foramen below the pyriformis, and is usually adherent for some distance to the deep surface of the great sciatic in the part of its course where it lies between the latter nerve and the bone. It then passes, under cover of the tendon of the obturator internus and the gemelli, and, having supplied the gemellus inferior, ends in the deep or anterior surface of the quadratus femoris, and in the posterior part of the capsule of the hip-joint.

6. The **small sciatic nerve** springs from the posterior aspect of the second and third sacral nerves, and, passing downwards, escapes through the great sacro-sciatic foramen by passing below the pyriformis. It then runs downwards on the posterior surface of the great sciatic nerve, under cover of the gluteus maximus muscle, to which it furnishes a branch. This branch is probably a portion of the inferior gluteal nerve, which has adhered in a part of its course to the small sciatic. Emerging from beneath the gluteus maximus it crosses the biceps, accompanied by a branch of the sciatic artery, and passing down, beneath the deep fascia it enters the popliteal space and pierces the deep fascia of the leg a little below the knee, ending in the integument of the upper part of the calf, where it may communicate with the external saphenous nerve. In its course down the thigh it gives off numerous branches, which pierce the fascia lata to supply the skin covering the back of the thigh and the popliteal space. At the lower border of the gluteus maximus it gives off *(a)* reflected branches, and *(b)* a large branch termed the **long pudendal nerve.**

Fig. 465.—Diagram of the Lumbar and Sacral Plexuses. (Modified from Paterson.)


FROM LAST THORACIC
FIRST LUMBAR
SECOND LUMBAR
GENITO-CRURAL
ILIO-HYPOGASTRIC
ILIO-INGUINAL
THIRD LUMBAR
EXTERNAL CUTANEOUS
FOURTH LUMBAR
OBTURATOR
ACCESSORY OBTURATOR
FIFTH LUMBAR
BRANCH TO ILIACUS
FIRST SACRAL
ANTERIOR CRURAL
SECOND SACRAL
SUPERIOR GLUTEAL
THIRD SACRAL
INFERIOR GLUTEAL
VISCERAL
FOURTH SACRAL
PERFORATING CUTANEOUS
PERINÆAL
GREAT SCIATIC
FIFTH SACRAL
NERVE TO COCCYGEUS
NERVE TO QUADRATUS FEMORIS
NERVE TO LEVATOR ANI
FIRST COCCYGEAL
EXTERNAL POPLITEAL SECTION
EP
IP
INTERNAL POPLITEAL SECTION
VISCERAL
TO HAMSTRINGS
SMALL SCIATIC
PUDIC
NERVE TO OBTURATOR INTERNUS

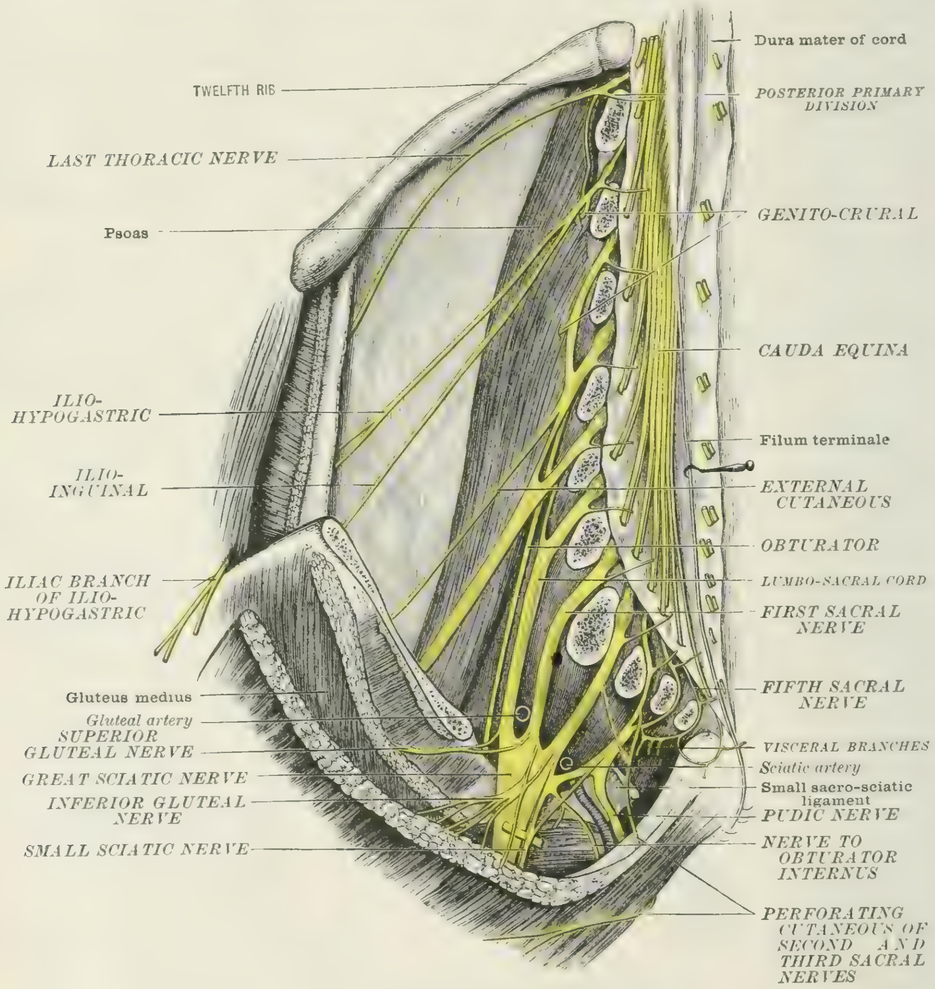
(a) The **reflected branches,** three or four in number, wind round the lower

border of the gluteus maximus, and, having pierced the deep fascia, supply the integument covering the lower and outer part of that muscle.

(*b*) The **long pudendal nerve,** or **nerve of Soemmerring,** winds round the origin of the hamstring muscles, just below the ischial tuberosity, giving twigs to the integument on the inner and upper part of the thigh, and then curves upwards and forwards towards the external genitals. Having pierced Colles's fascia, it communicates with the superficial perinæal nerves, and ends in the integument of the scrotum. In the female it is distributed in a similar manner to the labium majus.

FIG. 466.—A DISSECTION OF THE LUMBAR AND SACRAL PLEXUSES, FROM BEHIND.

(The anterior crural nerve is placed between the external cutaneous and obturator nerves.)


TWELFTH RIB
LAST THORACIC NERVE
Psoas
ILIO-HYPOGASTRIC
ILIO-INGUINAL
ILIAC BRANCH OF ILIO-HYPOGASTRIC
Gluteus medius
Gluteal artery
SUPERIOR GLUTEAL NERVE
GREAT SCIATIC NERVE
INFERIOR GLUTEAL NERVE
SMALL SCIATIC NERVE
Dura mater of cord
POSTERIOR PRIMARY DIVISION
GENITO-CRURAL
CAUDA EQUINA
Filum terminale
EXTERNAL CUTANEOUS
OBTURATOR
LUMBO-SACRAL CORD
FIRST SACRAL NERVE
FIFTH SACRAL NERVE
VISCERAL BRANCHES
Sciatic artery
Small sacro-sciatic ligament
PUDIC NERVE
NERVE TO OBTURATOR INTERNUS
PERFORATING CUTANEOUS OF SECOND AND THIRD SACRAL NERVES

7. The **nerve to the obturator internus** arises from the front of the plexus from the fifth lumbar and the first and second sacral nerves. It passes through the great sacro-sciatic foramen, below the pyriformis, and crosses the base of the ischial spine, being placed on the outer side of the pudic vessels. Having furnished a twig to the superior gemellus, it enters the lesser sacro-sciatic foramen, and ends in the obturator internus.

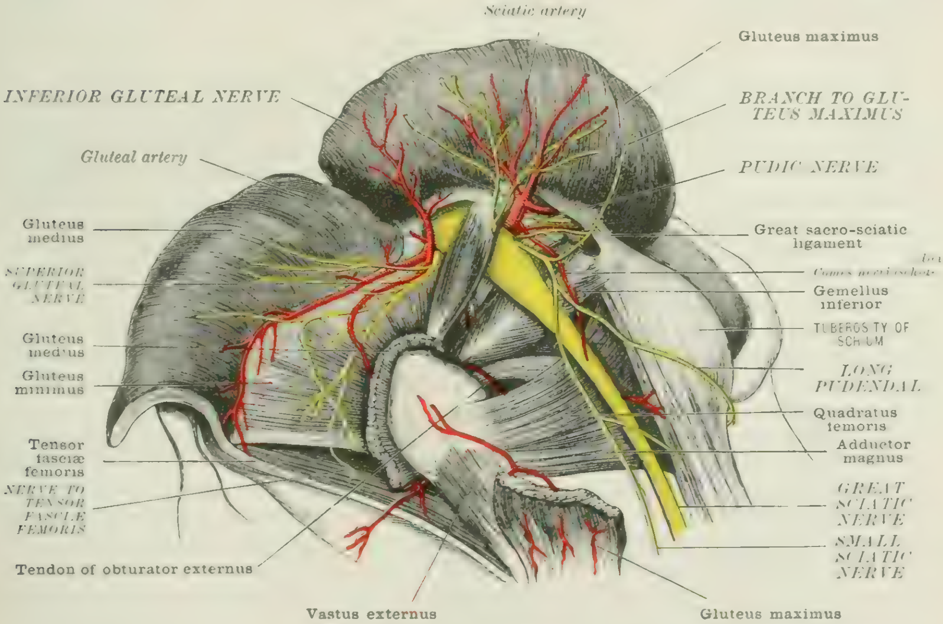
8. The **perforating cutaneous** nerve rises from the second and third sacral nerves. It runs in the angular interval between the great and lesser sacro-sciatic

ligaments, and then, perforating the former ligament, runs between it and the gluteus maximus. It then winds round the border of that muscle, behind the ischio-rectal fossa, and supplies the integument covering the lower and inner part of the muscle (figs. 464 and 466).

TERMINAL BRANCHES.—1. The **pudic nerve** arises by three roots from the anterior divisions of the second, third, and fourth sacral nerves, and escapes from the pelvis by passing through the great sacro-sciatic foramen, below the pyriformis. It crosses the posterior surface of the small sacro-sciatic ligament, near the attachment of that ligament to the spine of the ischium, and to the inner side of the pudic vessels. It then accompanies the pudic vessels through the small sacro-sciatic foramen, and enters a canal formed by a delamination of the parietal pelvic fascia (Alcock's canal), and, having given off the inferior hæmorrhoidal nerve, terminates by dividing into the perinæal nerve and the dorsal nerve of the penis. At its origin, the pudic nerve is often connected in a plexiform manner with the nerve to the obturator internus.

FIG. 467.—A DISSECTION OF THE NERVES IN THE GLUTEAL REGION.

(The gluteus maximus and gluteus medius have been divided near their insertions, and thrown upwards.)


Sciatic artery
Gluteus maximus
INFERIOR GLUTEAL NERVE
BRANCH TO GLUTEUS MAXIMUS
Gluteal artery
PUDIC NERVE
Gluteus medius
Great sacro-sciatic ligament
SUPERIOR GLUTEAL NERVE
Comes nervi ischiad.
Gemellus inferior
TUBEROSITY OF ISCHIUM
Gluteus medius
Gluteus minimus
LONG PUDENDAL
Quadratus femoris
Tensor fasciæ femoris
Adductor magnus
NERVE TO TENSOR FASCIÆ FEMORIS
GREAT SCIATIC NERVE
SMALL SCIATIC NERVE
Tendon of obturator externus
Vastus externus
Gluteus maximus

(*a*) The **inferior hæmorrhoidal nerve** pierces the wall of Alcock's canal, and passes inwards through the fatty tissue which occupies the ischio-rectal fossa. It is deeply placed at the outer part of the fossa, but becomes superficial as it approaches the anus. It divides into terminal twigs, some of which supply the external sphincter ani, while others are distributed to the adjacent integument.

(*b*) The **perinæal nerve** runs for a short distance in Alcock's canal at a lower level than the pudic vessels, and then divides into cutaneous and muscular divisions. The **cutaneous division** takes the form of two nerves, which are termed posterior and anterior superficial perinæal nerves. The **posterior** or **external superficial perinæal nerve** escapes from Alcock's canal at the anterior part of the ischio-rectal fossa, pierces the base of the triangular ligament, winds round the transverse perinæal muscle, and passes forwards under cover of Colles's fascia. It then divides into several long slender twigs, which communicate with the anterior superficial perinæal and long pudendal nerves, and end in the integuments of the scrotum. In the female they are distributed in a similar manner to the labium majus. The

anterior or **internal superficial perinæal nerve** appears a little further forwards than the preceding nerve; it pierces the base of the triangular ligament, and usually passes through the fibres of the transverse perinæal muscle. Its terminal offsets accompany the branches of the posterior perinæal nerve, and have a similar distribution. The **muscular division** of the perinæal nerve is more deeply placed than the cutaneous division. It breaks up into the following branches: a twig to the bulb of the urethra, and branches to supply the transversus perinæi, erector penis (or clitoridis), accelerator urinæ (or sphincter vaginæ), and compressor urethræ muscles.

(*c*) The **dorsal nerve of the penis,** which is placed at its origin below the pudic artery, crosses that vessel and courses along above it. It insinuates itself between the layers of the triangular ligament, and lies close to the bone at the outer side of the pudic vessels. It then pierces the anterior layer of the triangular ligament, and, having furnished a branch to the corpus cavernosum, passes between the bone and the crus penis, and is directed downwards between the layers of the suspensory ligament on the dorsum penis external to the dorsal artery. Having given off twigs to the prepuce, it ends in branches to the glans. As it runs on the dorsum penis the nerve is under cover of a thin strong fascia, and often appears in the form of two or three flattened parallel bundles. The **dorsal nerve of the clitoris** is distributed in a similar manner to the dorsal nerve of the penis, but is of much smaller size.

2. The Great Sciatic Nerve

The **GREAT SCIATIC NERVE** is the largest nerve in the body. It is, as above mentioned, the main termination of the sacral plexus, and commences at the lower border of the great sacro-sciatic foramen. It is directed vertically down the thigh, and terminates a little below the middle of the thigh by dividing into the **external** and **internal popliteal nerves.** In this course it is covered by the skin and fasciæ, the gluteus maximus, the long head of the biceps, and the small sciatic nerve. Its deep or anterior relations are the following, taken in order from above downwards: the ischium, gemellus superior, tendon of obturator internus, gemellus inferior, quadratus femoris, and adductor magnus.

The great sciatic nerve consists of two parts, the external and the internal popliteal, which are usually bound together into a single trunk by a connective tissue sheath; sometimes, however, they remain separate, a great sciatic nerve, in the proper sense of the word, being absent.

About the middle of the thigh the external popliteal part supplies a twig containing filaments of the fifth lumbar and the first and second sacral nerves to the short head of the biceps. At the upper part of the thigh the internal popliteal portion gives branches to the long head of the biceps, the semitendinosus, the semimembranosus, and the adductor magnus. There are always two branches to the semitendinosus, one to each belly, and they contain filaments of fifth lumbar and the first and second sacral nerves. The branch to the adductor magnus supplies the ischial section of that muscle by filaments derived from the fourth and fifth lumbar nerves, it is usually given off with the branch to the semimembranosus which also contains fibres of the first sacral nerve. The branch to the long head of the biceps contains fibres from the first, second, and third sacral nerves. The **EXTERNAL POPLITEAL NERVE,** formed of fibres derived from the fourth and fifth lumbar and the first and second sacral nerves, enters the superior angle of the popliteal space and runs downwards and outwards in contact with the inner border of the biceps. It leaves the space by passing between the biceps tendon and the outer head of the gastrocnemius, it crosses the popliteus and the inferior external articular artery, then it winds round the neck of the fibula between the bone and the peroneus longus muscle, and terminates by dividing into the recurrent articular, the musculo-cutaneous, and the anterior tibial nerves.

Branches.—The branches of the external popliteal nerve may be classified into articular, cutaneous, and terminal.

(1) The **articular branches** accompany the superior and inferior external articular branches of the popliteal artery, and are distributed to the knee-joint.

(2) The **cutaneous branches** are two in number; they often arise by a common

trunk. One of these, the external cutaneous nerve, which contains fibres from the fifth lumbar and the first and second sacral nerves is distributed to the skin covering the outer and upper part of the leg. The other branch, the **nervus communicans peronei or fibularis,** containing fibres from the same roots, runs downwards and inwards beneath the deep fascia, and joins the nervus communicans tibialis to form the external or short saphenous nerve (page 817).

(3) The **recurrent articular nerve** ends principally in the upper part of the tibialis anticus muscle. A few fine filaments accompany the anterior tibial recurrent artery to the front of the knee-joint, some pass the superior tibio-fibular articulation, and others to the head of the tibia.

(4) The **musculo-cutaneous nerve,** containing fibres from the fourth and fifth lumbar and the first sacral nerves, is directed downwards through the substance of the peroneus longus, and is afterwards placed between the peronei and extensor longus digitorum. Having given off branches to supply these muscles, it divides into an external and an internal branch; these branches pierce the deep fascia in the line of the intermuscular septum between the peronei and the extensor group of muscles. The **external branch** runs downwards, in front of the anterior annular ligament, and divides into the following branches: a twig which communicates with the short saphenous; a branch which divides to supply the adjacent sides of the fourth and fifth toes; and a branch which communicates with the internal division of the musculo-cutaneous nerve. The **internal branch** crosses the anterior annular ligament about an inch to the inner side of the external branch, and divides into four branches: the first of these communicates with the external branch, forming with it a nerve which bifurcates to supply the adjacent sides of the third and fourth toes; the second divides to be distributed to the contiguous sides of the second and third toes; the third communicates with the internal terminal branch of the anterior tibial at the cleft between the great and second toes; and the fourth supplies the inner border of the great toe.

In their course across the dorsum of the foot the branches of the musculo-cutaneous nerve pass beneath the dorsal venous arch, and from the two main divisions of the nerve a number of collateral twigs are given off, which supply the integument of the lower part of the front of the leg and the dorsum of the foot.

(5) The **anterior tibial nerve,** formed from fibres of the fourth and fifth lumbar and the first sacral nerves, pierces the intermuscular septum between the peronei and extensors, and, having traversed the upper fibres of the extensor longus digitorum, runs downwards on the interosseous membrane between the last-named muscle and the tibialis anticus; lower down it is placed between the tibialis anticus and the extensor longus hallucis. It crosses beneath the extensor longus hallucis, passes under cover of the anterior annular ligament, and terminates in front of the bend of the ankle by dividing into an external and an internal branch. In this course it is placed external to the anterior tibial artery in the upper third of the leg; it lies on the anterior surface of that vessel in the middle third, and in the remainder of its course it is again external to the artery.

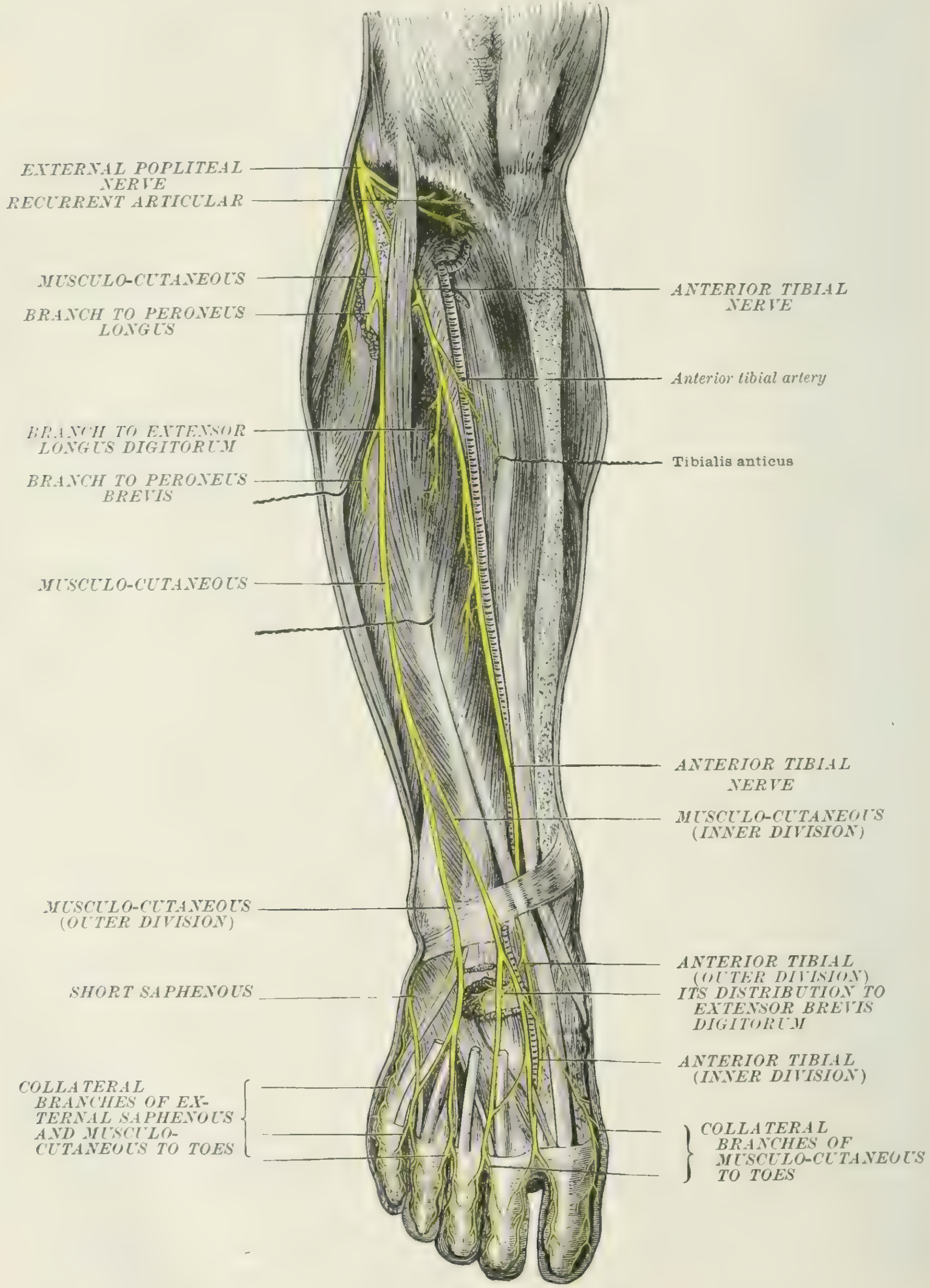
Branches.—In addition to the two terminal branches above mentioned, the anterior tibial nerve gives off an articular twig to the ankle-joint, and branches to supply the tibialis anticus, extensor longus hallucis, extensor longus digitorum, and peroneus tertius. The branches destined for the two latter muscles arise in common, and take the form of a long slender nerve which runs along the inner side of the muscles, supplying them with numerous twigs.

The **external branch** is directed outwards under cover of the extensor brevis digitorum, and, having supplied that muscle, ends in twigs which are distributed to the tarsal articulations. This nerve presents a gangliform enlargement near its termination, thus resembling the posterior interosseous nerve in the superior extremity, and from its terminal branches filaments pass to the interosseous spaces, where they anastomose with branches of the external plantar nerve and supply the tarso-metatarsal articulations and one or more dorsal interossei muscles.

The **internal branch** is directed forwards towards the interval between the first and second toes, where it is joined by a twig from the musculo-cutaneous, and then divides to supply the contiguous margins of the above-mentioned toes. In its course on the dorsum pedis it lies to the outer side of the dorsal artery of the foot.

and it is crossed on its superficial surface by the innermost division of the extensor brevis digitorum. In addition to supplying the integument in the area above mentioned, it also gives branches to the tarso-metatarsal articulations and to the first dorsal interosseous muscle.

Fig. 468.—Distribution of the Musculo-cutaneous and Anterior Tibial Nerves on the Anterior Aspect of the Leg and on the Dorsum of the Foot.—(Hirschfeld and Leveillé.)


EXTERNAL POPLITEAL NERVE
RECURRENT ARTICULAR
MUSCULO-CUTANEOUS
BRANCH TO PERONEUS LONGUS
BRANCH TO EXTENSOR LONGUS DIGITORUM
BRANCH TO PERONEUS BREVIS
MUSCULO-CUTANEOUS
MUSCULO-CUTANEOUS (OUTER DIVISION)
SHORT SAPHENOUS
COLLATERAL BRANCHES OF EXTERNAL SAPHENOUS AND MUSCULO-CUTANEOUS TO TOES
ANTERIOR TIBIAL NERVE
Anterior tibial artery
Tibialis anticus
ANTERIOR TIBIAL NERVE
MUSCULO-CUTANEOUS (INNER DIVISION)
ANTERIOR TIBIAL (OUTER DIVISION)
ITS DISTRIBUTION TO EXTENSOR BREVIS DIGITORUM
ANTERIOR TIBIAL (INNER DIVISION)
COLLATERAL BRANCHES OF MUSCULO-CUTANEOUS TO TOES

The **INTERNAL POPLITEAL NERVE,** formed of fibres from the fourth and fifth lumbar and the first, second, and third sacral nerves, is larger than the external popliteal nerve; it runs downwards, following the same direction as the great sciatic, to reach the lower border of the popliteus muscle, where it is continued into the posterior tibial nerve. In this course it occupies the middle vertical diameter of the popliteal space, and is the most superficially placed of the important contents of that space. It is overlapped by the hamstring muscles above and by the heads of the gastrocnemius below; but is covered only by the skin and fasciæ for about two inches above the line of the knee-joint. The popliteal vein intervenes between the internal popliteal nerve and the artery, and the nerve is on a plane superficial to the vessels. In the upper part of the popliteal space the vessels are internal to the nerve; at the level of the knee-joint they are immediately in front of the nerve; and at the lower part of the space they are placed external to it.

Branches.—The branches of the internal popliteal nerve may be classified into cutaneous, articular, muscular, and terminal.

(1) The **cutaneous branch,** the **nervus communicans tibialis,** containing fibres from the first and second sacral nerves, arises from the internal popliteal about the centre of the popliteal space, and runs vertically downwards, under cover of the deep fascia, to reach the interval between the two heads of the gastrocnemius; then, inclining a little outwards, it pierces the deep fascia, and unites with the communicans fibularis to form the short saphenous nerve. The **external** or **short saphenous nerve** is formed about the middle of the calf (sometimes higher up or lower down), and runs downwards and outwards, accompanied by the vein of the same name, to reach the interval between the external malleolus and the calcaneum. It crosses superficial to the external annular ligament, and then runs forwards along the outer border of the foot, supplying numerous twigs to the integument of the region. Having communicated with the external branch of the musculo-cutaneous, it terminates by supplying the integument on the outer side of the little toe.

Varieties.—In a large number of cases the distribution of this nerve is much more extensive. It may supply the fifth and fourth toes and the outer border of the third. In some cases the communicans fibularis does not join the communicans tibialis, but ends independently in the integuments of the calf.

(2) The **muscular branches** of the internal popliteal nerve are distributed to the gastrocnemius, soleus, plantaris, and popliteus muscles. There is a separate branch for each head of the gastrocnemius, containing fibres from the first and second sacral nerves. The branches to the plantaris and popliteus muscles are formed of fibres from the fourth and fifth lumbar and first sacral nerves. The branch to the popliteus arises lower down than the other branches. It crosses the superficial surface of the popliteal artery to reach the outer side of that vessel, runs downwards on the posterior surface of the popliteus, and winds round the lower border of that muscle to gain its deep or anterior surface, where it ends in the muscular substance; before it turns round the lower border of the muscle, it gives a branch to the superior tibio-fibular articulation, another to the tibia along the medullary artery, and a long branch to the interosseous membrane; the latter gives twigs to the anterior and posterior tibial arteries and then runs down in the interosseous membrane and ends in the inferior tibiofibular articulation. The nerve to the soleus is relatively large, it crosses the plantaris to gain the posterior surface of the soleus carrying fibres of the fifth lumbar and the first and second sacral nerves.

(3) The **articular branches** are three in number, and accompany the superior and inferior internal articular and the azygos branches of the popliteal artery, to be distributed to the knee-joint.

The **POSTERIOR TIBIAL NERVE** contains fibres derived from the fourth and fifth lumbar and the first and second sacral nerves; it is the terminal branch of the internal popliteal, or rather the direct continuation of that nerve. It runs downwards with an inclination inwards to reach the interval between the inner malleolus and the os calcis, and, having passed under cover of the origin of the abductor hallucis muscle, terminates by dividing into the internal and external plantar nerves, at a point midway between the tip of the internal malleolus and the most prominent part of the os calcis. In the upper part of its course it is covered by the gastrocnemius, plantaris, and soleus muscles, and by the intermuscular part of the deep fascia of the leg. Lower down, as it approaches the ankle, it is covered only by the skin and fasciæ. Its anterior relations are the tibialis posticus in the upper and the flexor longus digitorum and the tibia in the lower portion of its course. The posterior tibial vessels are placed externally to its upper part; above the middle of the leg they cross in front of the nerve, and run downwards parallel to its inner side.

Branches.—The posterior tibial nerve supplies the three deep muscles of the calf, viz. the *tibialis posticus*, *flexor longus digitorum*, and *flexor longus hallucis*, the two former by twigs from the fifth lumbar and the first sacral nerves, whilst the latter receives additional fibres from the second sacral nerve, and it gives a branch to the soleus. It also furnishes one or two articular filaments to the ankle-joint, and gives off a cutaneous branch, the internal calcanean.

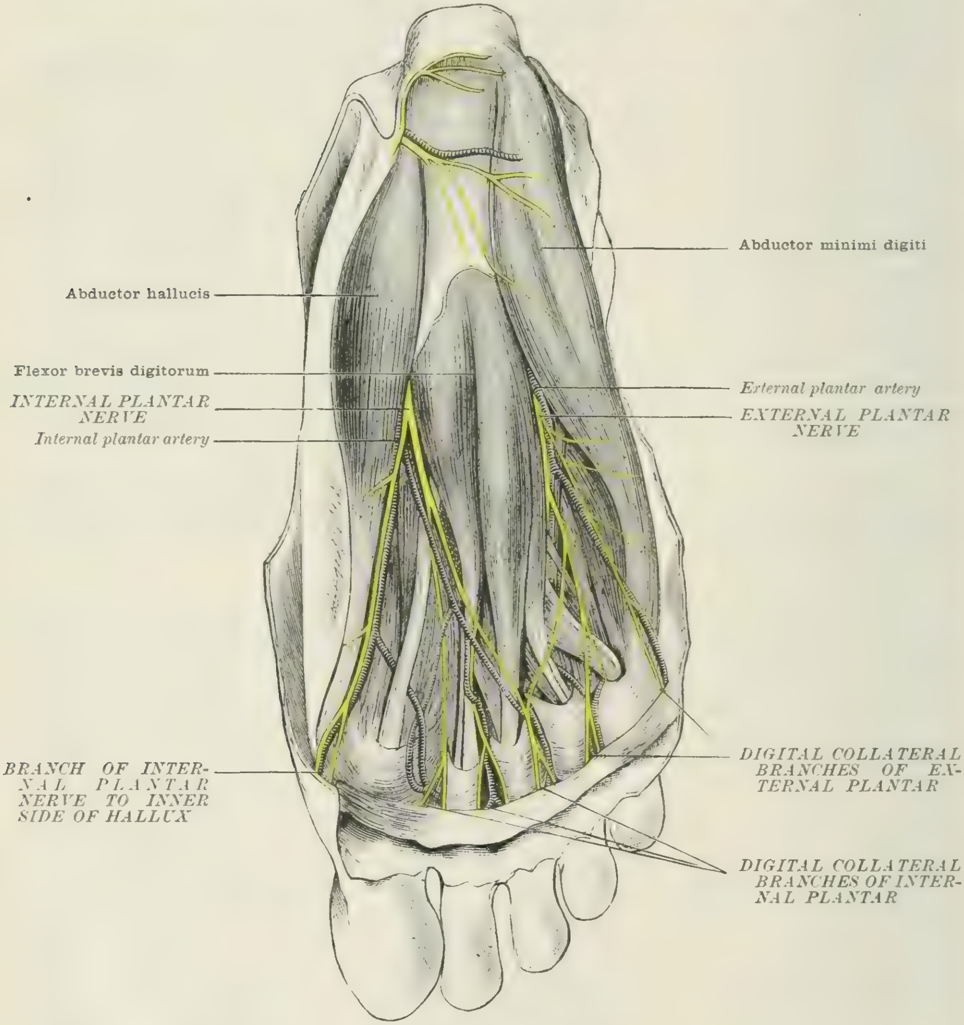


FIG. 469.—SUPERFICIAL NERVES IN THE SOLE OF THE FOOT. (Ellis.)
Abductor minimi digiti
Abductor hallucis
Flexor brevis digitorum
External plantar artery
INTERNAL PLANTAR NERVE
EXTERNAL PLANTAR NERVE
Internal plantar artery
DIGITAL COLLATERAL BRANCHES OF EXTERNAL PLANTAR
BRANCH OF INTERNAL PLANTAR NERVE TO INNER SIDE OF HALLUX
DIGITAL COLLATERAL BRANCHES OF INTERNAL PLANTAR

(1) The **internal calcanean** or **calcaneo-plantar cutaneous branch** contains fibres from the first and second sacral nerves. It arises from the posterior tibial nerve a little above the level of the inner malleolus, and passes under cover of the internal annular ligament, where it divides into several branches. These branches

pierce the internal annular ligament, accompanying the branches of the internal calcanean artery, and are distributed to the thick fascia and integument which covers the heel and adjacent part of the sole.

(2) The **internal plantar nerve** is formed of fibres from the fourth and fifth lumbar, and the first and second sacral nerves. It is the larger of the two terminal branches of the posterior tibial, and corresponds in its distribution to the median nerve in the hand. It runs forwards in the interval between the abductor hallucis and the flexor brevis digitorum; gives off branches to supply both these muscles, and a number of cutaneous twigs which appear in the interval between the middle and internal parts of the plantar fascia. It also supplies the astragalo-navicular and the internal intercuneiform joints. Near the level of the tarso-metatarsal articulation it terminates by dividing into four digital branches. The **first digital branch** gives off a branch to supply the flexor brevis hallucis, and then runs along the inner side of the great toe as far as the extremity of that digit. The **second branch** gives off a twig to supply the first or innermost lumbrical muscle, and then divides into two collateral branches which supply the adjacent sides of the great and second toes. The **third branch** divides in a similar manner to supply the contiguous sides of the second and third toes. The **fourth branch** communicates with the superficial division of the external plantar, and divides to supply the adjacent sides of the third and fourth toes. The muscular twigs to the flexor brevis hallucis and the first lumbrical muscle contain fibres from the fifth lumbar and first sacral nerves.

(3) The **external plantar nerve** is formed by fibres of the first and second sacral nerves. It shows many points of resemblance to the distribution of the ulnar nerve in the hand. From its origin, at the termination of the posterior tibial nerve, it is directed outwards and forwards between the flexor brevis digitorum and the flexor accessorius. In this part of its course it supplies the accessorius, the abductor minimi digiti, and the calcaneo-cuboid joint. It is then directed forwards in the interval between the last-named muscle and the flexor brevis digitorum, and terminates at the level of the tarso-metatarsal articulations by dividing into a superficial and a deep division. Previous to its division it gives off several cutaneous twigs, which appear in the interval between the middle and external divisions of the plantar fascia. The **superficial division** divides into two digital nerves, an external and an internal. The **internal branch** supplies the interosseous muscles which occupy the fourth interosseous space, and, having communicated with the internal plantar, divides into two collateral branches which supply the contiguous sides of fourth and fifth toes. The **external branch** supplies the flexor brevis minimi digiti, and is then directed along the outer border of the little toe to terminate at the extremity of that digit. The **deep division** of the external plantar nerve runs inwards and forwards on the dorsal or deep surface of the flexor tendons, and ramifies in the interval between these tendons and the interosseous muscles. It supplies the three outer lumbrical muscles, the interosseous muscles occupying the three inner interosseous spaces, the transversus pedis, and the adductor hallucis, and it gives branches to the adjacent articulations.

TABLE SHOWING RELATIONS OF LUMBAR AND SACRAL NERVES TO BRANCHES OF LUMBAR AND SACRAL PLEXUSES

NERVE ROOTS.	NERVES.
1 L.	Ilio-hypogastric ,, inguinal
1 and 2 L.	Genito-crural
2 and 3 L.	External cutaneous
2, 3, and 4 L.	Anterior crural Obturator
4, 5 L., and 1 S.	Superior gluteal Nerve to quadratus femoris
4, 5 L., 1 and 2 S.	Gt. sciatic (ext. poplit. part)
4, 5 L., 1, 2, and 3 S.	Gt. sciatic (int. poplit. part)

TABLE SHOWING RELATIONS OF LUMBAR AND SACRAL NERVES TO BRANCHES OF LUMBAR AND SACRAL PLEXUSES.—*Continued*

NERVE ROOTS.	NERVES.
5 L., 1 and 2 S.	Inferior gluteal Nerve to obturator internus
1 and 2 S.	Nerve to pyriformis
2 and 3 S.	Perforating cutaneous Small sciatic
2, 3, and 4 S.	Pudic

TABLE SHOWING RELATIONS OF MUSCLES OF LOWER EXTREMITY TO NERVES OF LUMBAR AND SACRAL PLEXUSES

NERVE ROOTS.	MUSCLES.	NERVES.
2 and 3 L.	Ilio-psoas	Anterior crural
	Sartorius	,, ,,
	Pectineus	,, ,,
	Adductor longus	Obturator
2, 3, and 4 L.	Gracilis	,,
	Adductor brevis	,,
3 and 4 L.	Quadriceps extensor	Anterior crural
	Obturator externus	Obturator
3, 4, and 5 L.	Adductor magnus	,, and gt. sciatic
4, 5 L., and 1 S.	Gluteus medius	Superior gluteal
	,, minimus	,, ,,
	Tensor fasc. femoris	,, ,,
	Semimembranosus	Gt. sciatic
	Plantaris	Internal popliteal
	Popliteus	,, ,,
	Quadratus femoris	Nerve to quad. fem.
	Inferior gemellus	,, ,, ,,
5 L. and 1 S.	Flex. long. digit.	Posterior tibial
	Tibialis posticus	,, ,,
	Flexor brev. digit.	Internal plantar
	,, ,, hallucis	,, ,,
	Abductor ,,	,, ,,
	First lumbrical	,, ,,
5 L., 1 and 2 S.	Superior gemellus	Nerve to obt. int.
	Obturator internus	,, ,,
	Gluteus maximus	Inferior gluteal
	Semitendinosus	Gt. sciatic
	Soleus	Int. poplit. and post. tib.
	Flex. long. hallucis	Posterior tibial
1 and 2 S.	Pyriformis	
	Gastrocnemius	Int. popliteal
	Flexor accessorius	External plantar
	Abd. min. digiti	,, ,,
	Plantar interossei	,, ,,
	Dorsal ,,	,, ,,
	Add. hallucis trans.	,, ,,
	,, ,, obliq.	,, ,,
1, 2, and 3 S.	Long head of biceps	Gt. sciatic
4, 5 L., and 1 S.	Ext. long. hall.	Anterior tibial
	,, ,, digit.	,, ,,
	,, brev. ,,	,, ,,
	Tibialis anticus	,, ,,
	Peroneus tertius	,, ,,
	,, longus	Musculo-cutaneous
	,, brevis	,, ,,

THE DISTRIBUTION OF THE CUTANEOUS BRANCHES OF THE SENSORY AND MIXED NERVES

The cutaneous filaments of the sensory and mixed nerves are distributed to definite regions of the surface of the body which are known as "cutaneous areas." Each cutaneous area has one special nerve of supply and the central part of the area receives that nerve alone, but wherever the borders of two areas meet they reciprocally overlap, therefore each margin of every cutaneous area receives two nerves of supply, its own nerve and that of an adjacent area, and of these sometimes one and sometimes the other preponderates.

The Cutaneous Areas of the Scalp

The limits of the cutaneous areas in the scalp region are indicated in Figs. 469A, 469B, but in general terms it may be said that the skin of the scalp in front of the pinna is supplied by four cutaneous nerves, the mesial part by the supratrochlear and the supraorbital branches of the first division of the fifth cranial nerve, and the lateral part by the temporal branch of the second division, and the auriculo-temporal branch of the third division of the same nerve.

The portion of the scalp behind the pinna also receives four cutaneous nerves: laterally it is supplied by the great auricular and small occipital branches of the cervical plexus which contain filaments from the second and third cervical nerves, and mesially it receives the great and smallest occipital nerves which are derived from the internal divisions of the posterior primary branches of the second and third cervical nerves respectively.

The Cutaneous Areas of the Face

With the exception of the skin over the posterior part of the masseter muscle the whole of the skin of the face is supplied by the branches of the fifth cranial nerve. The nose is supplied mesially by the supratrochlear, the infratrochlear, and the nasal branches of the first division, and laterally by the infraorbital branch of the second division. The upper eyelid is supplied by the supratrochlear, the supraorbital, and the lachrymal branches of the first division; the lower eyelid by the infratrochlear branch of the first division and by the infraorbital and the malar branches of the second division. The skin over the upper jaw and the malar bone is supplied by the infraorbital and malar branches of the second division, that over the buccinator muscle by the buccal branch of the third division, and that over the lower jaw, from before backwards, by the mental, buccal, and auriculo-temporal branches of the third division, except a small part near the posterior border which receives its supply from the great auricular nerve.

The Cutaneous Areas of the Pinna

The upper two-thirds of the outer surface of the pinna are supplied by the auriculo-temporal branch of the third division of the fifth cranial nerve, and the lower third by twigs of the great auricular nerve. The cranial surface of the pinna is supplied in the lower part of its extent by the great auricular nerve, and in the upper part by the small occipital nerve. The posterior surface of the external auditory meatus receives filaments from the auricular branch of the tenth cranial nerve.

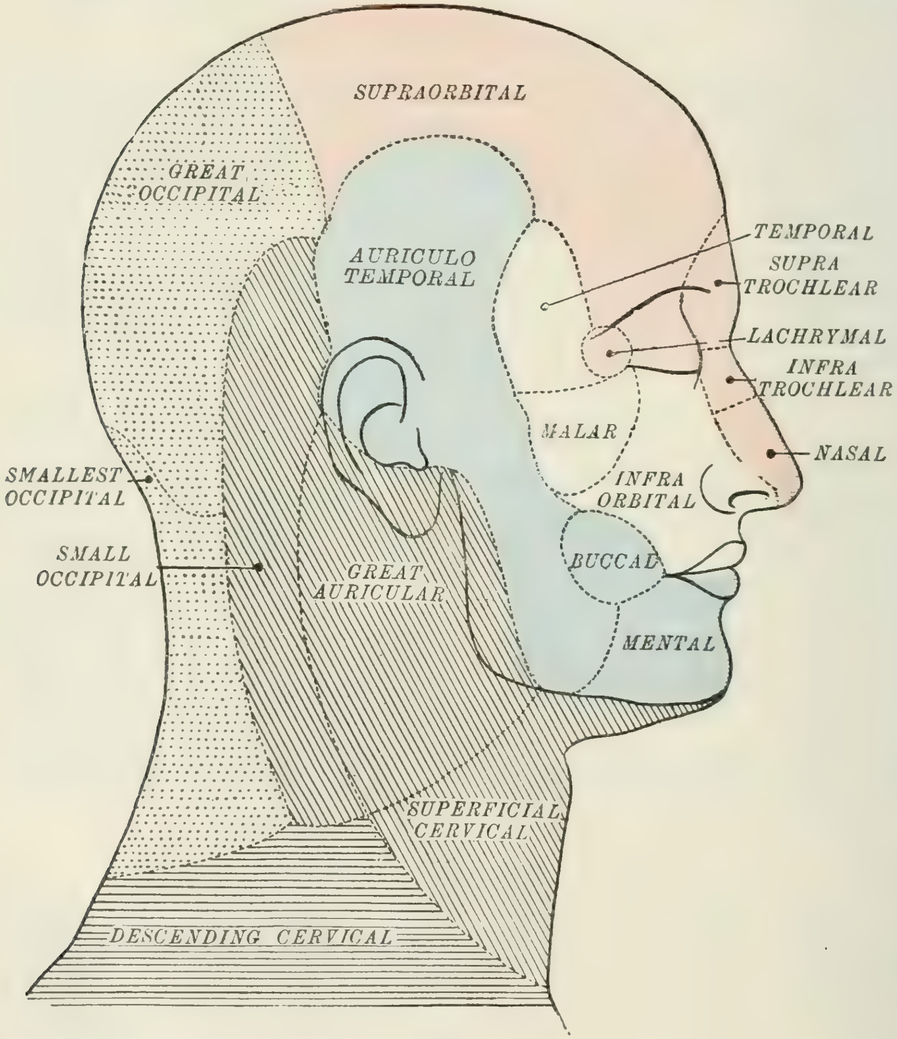
The Cutaneous Areas of the Neck

The skin over the anterior part of the neck is supplied by the superficial cervical branch of the cervical plexus, which contains filaments of the second and third cervical nerves, and in the lower part of its extent by the suprasternal branch, which conveys twigs of the third and fourth cervical nerves (fig. 469A). The lateral part of the neck receives filaments from the second, third, and fourth cervical nerves by the great auricular, small occipital, and supraclavicular branches of the cervical plexus (fig. 469A), and posteriorly the skin of the neck is supplied by the small occipital nerve and by the internal branches of the posterior primary divisions of the cervical nerves from the second to the sixth inclusive (fig. 469B).

Fig. 469A.—Diagram of the Cutaneous Nerve Areas of the Head and Neck.

Red—First division of fifth. White—Second division of fifth.
Blue—Third division of fifth.

Dark shading—Posterior primary division of cervical nerve.
Oblique shading—Ascending and transverse superficial branches of cervical plexus.
Transverse shading—Descending superficial branches of cervical plexus.
It must be understood the boundaries of each area are not distinct; wherever two areas meet they overlap.


SUPRAORBITAL
GREAT OCCIPITAL
AURICULO TEMPORAL
TEMPORAL
SUPRA TROCHLEAR
LACHRYMAL
INFRA TROCHLEAR
MALAR
NASAL
SMALLEST OCCIPITAL
INFRA ORBITAL
SMALL OCCIPITAL
BUCCAL
GREAT AURICULAR
MENTAL
SUPERFICIAL CERVICAL
DESCENDING CERVICAL

The Cutaneous Areas of the Body

The skin over the anterior aspect of the body as far down as the second rib is supplied by the suprasternal and supraclavicular branches of the cervical plexus, which contain filaments from the third and fourth cervical nerves (fig. 469B); from the second rib to the lower part of the abdominal wall it receives the anterior cutaneous branches, and the anterior divisions of the lateral cutaneous branches of the dorsal nerves except the first, second, and twelfth (fig. 469B); and the skin over the lower and anterior part of the abdominal wall is supplied by the ilio-hypogastric branch of the first lumbar nerve.

The cutaneous supply of the lateral aspect of the body is derived from the lateral branches of the anterior primary divisions of the dorsal nerves from the second to the eleventh, and the skin over the posterior aspect of the body is supplied externally by the posterior divisions of the lateral branches of the dorsal nerves from the third to the eleventh, and internally by the posterior primary divisions of the dorsal nerves (fig. 469B), in the upper half by their internal branches and in the lower half principally by their external branches.

THE CUTANEOUS AREAS OF THE UPPER LIMB

The skin over the upper third of the deltoid muscle is supplied by the supra-acromial and supraclavicular branches of the cervical plexus, which contain filaments of the third and fourth cervical nerves, and that over the lower two-thirds by the circumflex nerve, which conveys fibres of the fifth and sixth cervical nerves (fig. 469B).

The skin over the front of the upper arm is supplied externally by the circumflex nerve above and by the superior external cutaneous branch of the musculo-spiral nerve below; the former contains filaments of both the fifth and sixth cervical nerves, and the latter filaments of the sixth alone. Internally the skin of the upper arm is supplied by the internal cutaneous nerve with filaments of the eighth cervical and first dorsal nerves, and by the lesser internal cutaneous and intercosto-humeral nerves which are derived from the first and second dorsal nerves. The back of the upper arm is supplied, externally, by the fifth and sixth cervical nerves through the circumflex nerve, and the external cutaneous branches of the musculo-spiral nerve; mesially by the eighth cervical nerve through the internal cutaneous branch of the musculo-spiral nerve, and internally by the first and second dorsal nerves through the lesser internal cutaneous and intercosto-humeral nerves (fig. 469).

The front of the forearm is divided into two areas, an external, which is supplied by the fifth and sixth cervical nerves through the musculo-cutaneous branch of the brachial plexus, and an internal, supplied by the eighth cervical and first dorsal nerves through the internal cutaneous nerve. On the back of the forearm there are three areas: an external, supplied by filaments of the fifth and sixth cervical nerves through the musculo-cutaneous nerve; a middle, which receives filaments of the sixth, seventh, and eighth cervical nerves through the inferior external cutaneous branch of the musculo-spiral nerve; and an internal, which receives the eighth cervical and first dorsal nerves through the internal cutaneous nerve (fig. 469B).

The front of the hand is supplied by the sixth, seventh, and eighth cervical nerves and by the first dorsal nerve through the radial branch of the musculo-spiral nerve and through the median and ulnar branches of the brachial plexus. The radial nerve supplies the radial side of the thumb by its palmar cutaneous branch; the remainder of the palm and the palmar aspects of the fingers are supplied by the median and ulnar nerves through their palmar cutaneous and digital branches, the median supplying three and a half digits and the ulnar the remaining one and a half (fig. 469B).

The dorsal aspect of the hand is supplied by the sixth, seventh, and eighth cervical nerves which reach it through the radial branch of the musculo-spiral nerve and through the median and ulnar nerves. The radial nerve supplies the outer part of the dorsum and the outer three and a half digits, except the lower parts of the index, middle, and half the ring digits which receive twigs from the median nerve, and the ulnar nerve supplies the ulnar half of the dorsum including the inner one and a half digits.

THE CUTANEOUS AREAS OF THE LOWER EXTREMITY

There are six cutaneous areas in the region of the buttock, three upper and three lower. Of the upper areas the external is supplied by the anterior primary divisions of the last dorsal and first lumbar nerves through the iliac branches of the

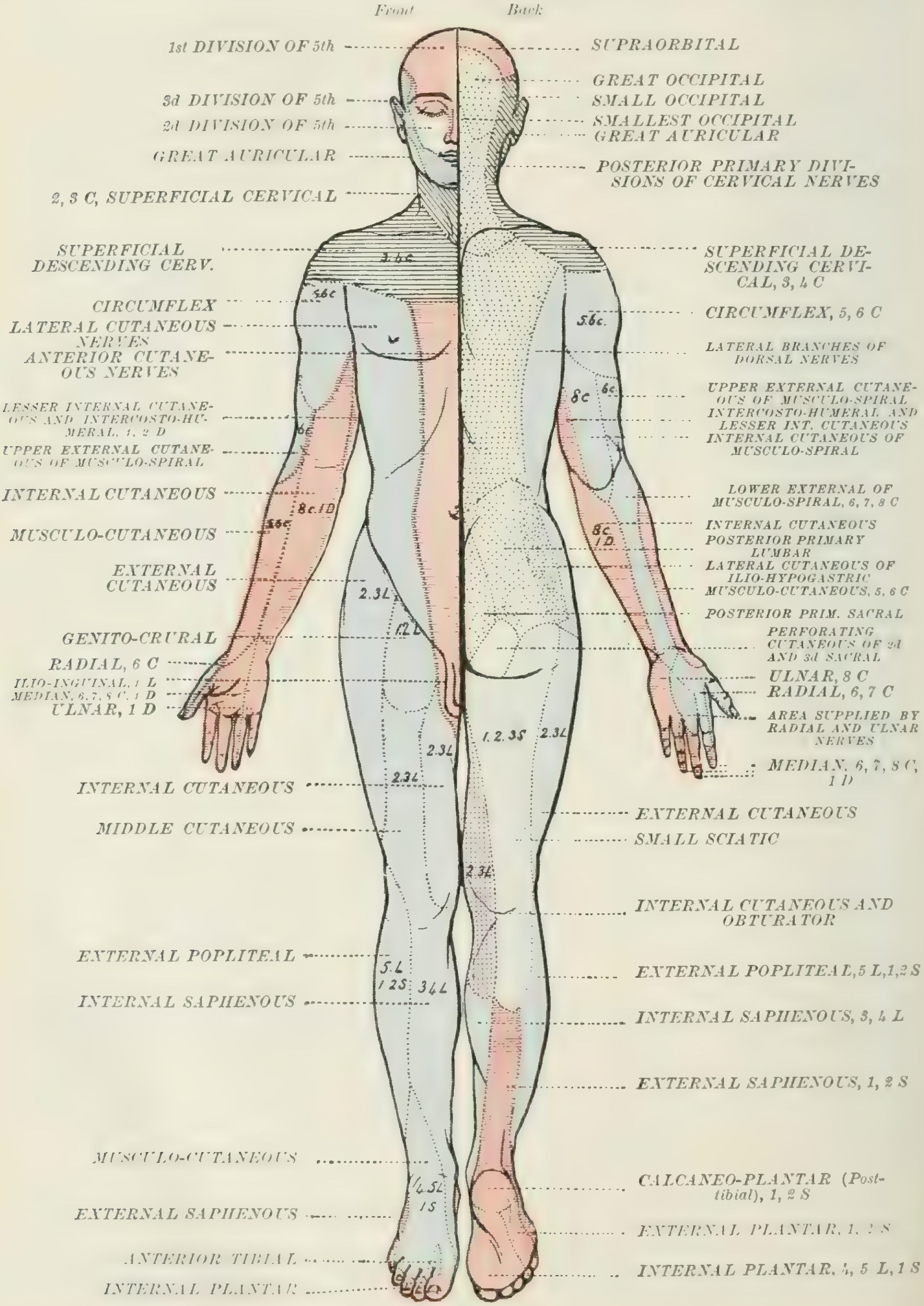
FIG. 469B.—DIAGRAM SHOWING THE AREAS OF DISTRIBUTION OF CUTANEOUS NERVES.

HEAD:—

Red—First division of fifth. White—Second division of fifth. Blue—Third division of fifth. Dark area—Posterior primary divisions of cervical nerves. Oblique and transverse shading—Branches of cervical plexus.

BODY AND LIMBS:—

Red—Anterior divisions of anterior primary branches. Blue—Posterior division of anterior primary branches. Two colors in one area indicate that the area is supplied by two sets of nerves, and it should be understood that wherever two nerve areas approach each other they overlap. The dotted blue area of small sciatic indicates that the nerve comes from the posterior part of anterior primary divisions of sacral nerves, but it supplies a flexor area. The area of the perforating cutaneous nerve is left uncoloured, because its true nature is uncertain. Dark shading—Posterior primary divisions. The numbers and initial letters refer to the nerve roots from which the nerves are derived.


Front
Back
1st DIVISION OF 5th
3d DIVISION OF 5th
2d DIVISION OF 5th
GREAT AURICULAR
2, 3 C, SUPERFICIAL CERVICAL
SUPERFICIAL DESCENDING CERV.
CIRCUMFLEX
LATERAL CUTANEOUS NERVES
ANTERIOR CUTANEOUS NERVES
LESSER INTERNAL CUTANEOUS AND INTERCOSTO-HUMERAL, 1, 2 D
UPPER EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
INTERNAL CUTANEOUS
MUSCULO-CUTANEOUS
EXTERNAL CUTANEOUS
GENITO-CRURAL
RADIAL, 6 C
ILIO-INGUINAL, 1 L
MEDIAN, 6, 7, 8 C, 1 D
ULNAR, 1 D
INTERNAL CUTANEOUS
MIDDLE CUTANEOUS
EXTERNAL POPLITEAL
INTERNAL SAPHENOUS
MUSCULO-CUTANEOUS
EXTERNAL SAPHENOUS
ANTERIOR TIBIAL
INTERNAL PLANTAR
SUPRAORBITAL
GREAT OCCIPITAL
SMALL OCCIPITAL
SMALLEST OCCIPITAL
GREAT AURICULAR
POSTERIOR PRIMARY DIVISIONS OF CERVICAL NERVES
SUPERFICIAL DESCENDING CERVICAL, 3, 4 C
CIRCUMFLEX, 5, 6 C
LATERAL BRANCHES OF DORSAL NERVES
UPPER EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
INTERCOSTO-HUMERAL AND LESSER INT. CUTANEOUS
INTERNAL CUTANEOUS OF MUSCULO-SPIRAL
LOWER EXTERNAL OF MUSCULO-SPIRAL, 6, 7, 8 C
INTERNAL CUTANEOUS
POSTERIOR PRIMARY LUMBAR
LATERAL CUTANEOUS OF ILIO-HYPOGASTRIC
MUSCULO-CUTANEOUS, 5, 6 C
POSTERIOR PRIM. SACRAL
PERFORATING CUTANEOUS OF 2d AND 3d SACRAL
ULNAR, 8 C
RADIAL, 6, 7 C
AREA SUPPLIED BY RADIAL AND ULNAR NERVES
MEDIAN, 6, 7, 8 C, 1 D
EXTERNAL CUTANEOUS
SMALL SCIATIC
INTERNAL CUTANEOUS AND OBTURATOR
EXTERNAL POPLITEAL, 5 L, 1, 2 S
INTERNAL SAPHENOUS, 3, 4 L
EXTERNAL SAPHENOUS, 1, 2 S
CALCANEO-PLANTAR (Post-tibial), 1, 2 S
EXTERNAL PLANTAR, 1, 2 S
INTERNAL PLANTAR, 4, 5 L, 1 S
3.4c
5.6c
6c
8c.1D
5.6c
2.3L
1.2L
2.3L
2.3L
5.L
1 2S
3.4L
4.5L
1S
5.6c.
6c
8c
8c
1D.
1.2.3S
2.3L
2.3L

twelfth dorsal and the ilio-hypogastric nerves; the middle upper area receives the external divisions of the posterior primary branches of the upper three lumbar nerves, and the inner and upper area is supplied by twigs from the external divisions of the posterior primary branches of the upper two or three sacral nerves (fig. 469B).

Of the lower three areas the outer receives filaments from the second and third lumbar nerves through the external cutaneous branch of the lumbar plexus, the middle area is supplied by the first, second, and third sacral nerves through the small sciatic nerve, and the inner area by the second and third sacral nerves through the perforating cutaneous branch of the sacral plexus (fig. 469B).

On the back of the thigh there are three areas. The external and the internal are supplied by the second and third lumbar nerves, the former through the external cutaneous branch of the lumbar plexus and the latter through the internal cutaneous branch of the anterior crural nerve; the middle area receives twigs from the first, second, and third sacral nerves through the small sciatic branch of the sacral plexus (fig. 469B).

The front of the thigh is supplied by the first, second, and third lumbar nerves, and there are five cutaneous areas; the outer receives twigs of the second and third lumbar nerves through the external cutaneous nerve. There are two mesial areas, an upper and a lower. The former is supplied by the crural branch of the genito-crural which conveys twigs of the first and second lumbar nerves, and the latter receives filaments of the second and third lumbar nerves through the middle cutaneous branch of the anterior crural nerve. The small upper and internal area is supplied by the first lumbar nerve through the ilio-inguinal branch of the lumbar plexus, and the lower internal area receives twigs of the second and third lumbar nerves through the internal cutaneous branch of the anterior crural nerve (fig. 469B).

The front of the knee is supplied by the second, third, and fourth lumbar nerves through the middle cutaneous, the internal cutaneous, and the long saphenous branches of the anterior crural nerve (fig. 469B).

The skin over the region of the popliteal space receives filaments internally from second, third and fourth lumbar nerves through the internal cutaneous branch of the anterior crural nerve and through the superficial division of the obturator nerve; mesially and externally it receives twigs of the first three sacral nerves through the small sciatic nerve (fig. 469B).

The skin of the front and inner side of the leg is supplied by the third and fourth lumbar nerves through the long saphenous branch of the anterior crural nerve, and the skin of the front and outer side of the leg receives filaments of the fifth lumbar, and the first and second sacral nerves through the external cutaneous branch of the external popliteal nerve. The skin of the lower and middle part of the anterior aspect of the leg is supplied by the musculo-cutaneous nerve which conveys filaments of the fourth and fifth lumbar and the first sacral nerve (fig. 469B).

In the skin of the back of the leg five areas can be distinguished, two internal, upper and lower, two middle, upper and lower, and an external. The upper and inner area is supplied by the second, third, and fourth lumbar nerves through the internal cutaneous branch of the anterior crural nerve and the superficial branch of the obturator nerve, the lower internal area receives filaments from the third and fourth lumbar nerves through the long saphenous nerve. The upper middle area is supplied by the first, second and third sacral through the small sciatic nerve, and the lower middle area by the first and second sacral nerves through the external saphenous nerve. The outer area is supplied by the fifth lumbar and the first and second sacral nerves through the external cutaneous branch of the external popliteal nerve (fig. 469B).

The skin of the dorsum of the foot is supplied principally by the fourth and fifth lumbar and by the first sacral nerves; the majority of the nerve filaments travel by the musculo-cutaneous nerve, but the adjacent sides of the first and second toes are supplied by the anterior crural nerve, and the outer side of the dorsum of the little toe is supplied by the first and second sacral nerves through the external saphenous nerve (fig. 469B).

The skin of the region of the heel is supplied by the first and second sacral nerves, on the inner surface and inner part of the under surface by means of the calcaneo-plantar branch of the posterior tibial nerve, and on its posterior, external, and lower aspects by the external saphenous nerve (fig. 469B).

The sole of the foot in front of the heel receives cutaneous filaments from the last two lumbar and the first two sacral nerves, the inner area, which includes the inner three and a half digits, being supplied by the internal plantar nerve which conveys filaments of the fourth and fifth lumbar and the first sacral nerve, and the outer area by the first and second sacral nerves through the external plantar nerve.

The inner side of the foot is supplied by the third and fourth lumbar nerves through the long saphenous nerve, and the outer side by the first and second sacral nerves through the external saphenous nerve (fig. 469B).

The skin of the scrotum and penis is supplied by the first lumbar nerve through the ilio-inguinal nerves, and the second and third sacral nerves through the perineal and dorsal penile branches of the pudic nerves (fig. 469B).

SYMPATHETIC NERVES

The **sympathetic nerves** were formerly supposed to be a separate system, linked, it is true, to the cerebro-spinal system by numerous communications, yet possessing, in their ganglia, a certain governing power independent of the cerebro-spinal axis. It is now very generally admitted that the sympathetic nerves are merely the visceral branches of the spinal nerves, but they differ from the somatic nerves in the following respects: (*a*) in the individual fibres being of smaller calibre than the somatic nerve-fibres; (*b*) in the great preponderance of non-medullated fibres; (*c*) in the fibres being interrupted in the nerve-cells, which are contained in a chain of ganglia which is called the gangliated cord of the sympathetic, and often also interrupted in secondary and tertiary ganglia, of which the semilunar ganglia and the nerve-cells in the plexuses of Auerbach and Meissner are examples; and (*d*) in the tendency that these nerves show to form extensive and closely-meshed plexuses.

The somatic nerves are the nerves which supply the body-wall as distinguished from the viscera. They have been described above as the cranial and spinal nerves.

Certain visceral nerves—for example, the visceral branches of the third and fourth sacral nerves—do not join the gangliated cord. While the sympathetic nerves, taken as a whole, can no longer be regarded as a separate system, certain ganglia connected with the sympathetic are capable of automatic action; for example, the ganglia in the heart and in the intestinal walls.

The sympathetic system, as usually described, consists of (*a*) a pair of gangliated cords which are placed on the front and sides of the vertebral column; and (*b*) three great prevertebral plexuses containing many ganglia; and (*c*) numerous terminal ganglion cells situated close to or within the various organs and vessels. One of the plexuses, the cardiac plexus, is contained in the thoracic cavity. The other two, which are termed the solar and hypogastric plexuses, are placed in the abdominal cavity. The gangliated cords will be first described.

GANGLIATED CORDS OF THE SYMPATHETIC

The **gangliated cords of the sympathetic** consist of a series of ganglia united together by intervening cords. These ganglia are of a reddish-grey colour, soft in consistence, but enclosed in tolerably firm investments of connective tissue. The nerve-cords uniting them are pearly grey in colour. Morphologically speaking, there should be thirty-one pairs of ganglia, that is to say, a pair corresponding to each pair of spinal nerves. We find, however, owing to the cohesion of certain ganglia, particularly in the cervical region, that the number is reduced to from twenty to twenty-three pairs. In the thoracic region the arrangement is the most typical, twelve pairs of ganglia corresponding to the twelve thoracic nerves being frequently present. In the thoracic region, also, the arrangement of the rami communicantes is most easily studied.

Each thoracic ganglion is connected with the anterior primary division of the corresponding spinal nerve by two **rami communicantes** (fig. 470A), a white and a grey. The white ramus consists of small medullated fibres which leave the spinal cord by the anterior nerve root and pass to the ganglion. Some of the fibres of the white ramus pass through the ganglion and leave the chain directly, or more generally after running upwards or downwards for some distance within it, by the **rami efferentes** (fig. 470A).

The rami efferentes pass to the prevertebral plexuses where they may end in arborizations round the cells of the ganglia, or passing through these ganglionic plexuses they end round the cells of the terminal ganglia, which are situated either close to or within the walls of the vessels and organs. Other fibres of the white rami afferentes terminate round the cells of the vertebral ganglia (ganglia of the chain).

From the cells of the various ganglia, vertebral, prevertebral, and terminal, non-medullated fibres arise which end in the walls of the viscera, vessels, and glands. Many of the non-medullated fibres which issue from the thoracic vertebral ganglia form the grey rami (fig. 470A). They pass to the spinal nerves. Some of them turn inwards along the posterior nerve roots to the membranes of the spinal cord and the walls of the spinal canal; others travel peripherally, with the branches of the nerve; they terminate in the blood vessels, hair muscles, and skin glands. The remaining non-medullated fibres, which issue from the vertebral ganglia, leave in the rami efferentes and pass through the prevertebral plexuses to their terminations (fig. 470A).

In addition to the fibres above mentioned, it is possible that there are also afferent (sensory) fibres passing from the viscera, glands, and vessels through the sympathetic ganglia to the posterior nerve roots and thence to the spinal cord.

Cranial portion of the sympathetic.—The small sporadic ganglia (ophthalmic, spheno-palatine, otic, and submaxillary), which have already been described in connection with the trigeminal nerve, are regarded by some anatomists as representing a cranial portion of the gangliated cord, and sympathetic fibres are undoubtedly given off from the ninth, tenth, and eleventh cranial nerves.

CERVICAL PORTION OF THE GANGLIATED CORD

The **cervical portion of the gangliated cord** consists of three ganglia united by intervening nerve-cords. Of these the superior cervical ganglion is the largest, and probably represents four coalesced ganglia; the middle cervical ganglion is the smallest, and represents two ganglia; the inferior, intermediate in size, is probably formed by the union of two ganglia. The cord takes a vertical course down the neck, and is in contact posteriorly with the prevertebral layer of the cervical fascia. Behind this fascia it corresponds to the rectus capitis anticus major above, and the longus colli below. These muscles and the prevertebral fascia intervene between the cord and the transverse processes of the cervical vertebræ. The internal carotid above, and the common carotid artery below, are placed in front of the gangliated cord, and the pneumogastric nerve is external to it.

Superior Cervical Ganglion

The **superior cervical ganglion** is a fusiform body, about one inch to an inch and a half in length (2.5 to 3.75 cm.). It corresponds to the transverse processes of the second and third (and sometimes the first) cervical vertebræ. Above, it is continued into a stout trunk which is called the ascending branch. Below, it ends in a cord which passes downwards to join the middle cervical ganglion. It is connected to the anterior primary divisions of the four upper cervical nerves by as many grey **rami communicantes.** Occasionally the number of rami is increased to five or six. The ganglion is occasionally constricted at intervals—these constrictions affording an indication of the individual ganglia by the coalescence of which the superior cervical ganglion is formed.

Branches.—The branches of the superior cervical ganglion are the ascending branch; branches which follow the distribution of the external carotid artery (**nervi molles**); branches of communication to cranial nerves; pharyngeal nerves; the superior cervical cardiac nerve, and branches to the upper cervical vertebræ and their ligaments.

1. The **ascending branch** enters the carotid canal in the temporal bone and divides into a larger external branch which forms the carotid plexus, and a smaller internal branch which ends in the cavernous plexus. These plexuses communicate frequently with one another around the artery, and may be regarded as different parts of the same plexus rather than distinct plexuses.

The **carotid plexus** is formed by repeatedly communicating branches, which follow the internal carotid artery in the carotid canal, keeping close to the outer side of that vessel. The following nerves arise from it: tympanic; great deep petrosal; and a communicating branch to the sixth nerve.

(*a*) The **tympanic branch** (small deep petrosal) enters a minute canal (carotico-tympanic canal) in the temporal bone, by which it is conducted to the tympanic plexus (page 768).

(*b*) The **great deep petrosal nerve** passes forwards and inwards through the cartilage which occupies the foramen lacerum medium, and unites with the great superficial petrosal to form the Vidian nerve (page 755).

(*c*) The **branches to the Gasserian ganglion** are given off from the plexus as it emerges from the carotid canal.

(*d*) The **branches to the sixth nerve** are very distinct, and can be easily seen when the cavernous sinus is opened. They join the abducens as it is crossing the outer side of the internal carotid artery.

The **cavernous plexus** is placed on the inner side of the internal carotid artery near the pituitary body. Its terminal offsets follow the ophthalmic and cerebral branches of the internal carotid artery. In addition to these it gives off the following branches:—

(*a*) **Communicating branches to the third, fourth,** and **ophthalmic division of the fifth cranial nerves.**

(*b*) The **sympathetic root of the lenticular ganglion.** This root is usually in the form of several fine filaments which enter the ganglion at its posterior border.

(*c*) Two or three fine twigs enter the pituitary body.

2. The **nervi molles** are given off from the anterior part of the superior cervical ganglion, and accompany the branches of the external carotid artery. We have already noted, in the description of the fifth cranial nerve, that the otic and submaxillary ganglia receive their sympathetic roots from plexuses of the sympathetic which reach them *viâ* the middle meningeal and facial arteries respectively. In addition to these roots to the ganglia, vaso-motor branches, and twigs which enter the parotid gland, are given off. Other twigs, taking a downward direction, enter the intercarotic and thyroid bodies; the latter follow the course of the superior thyroid vessels.

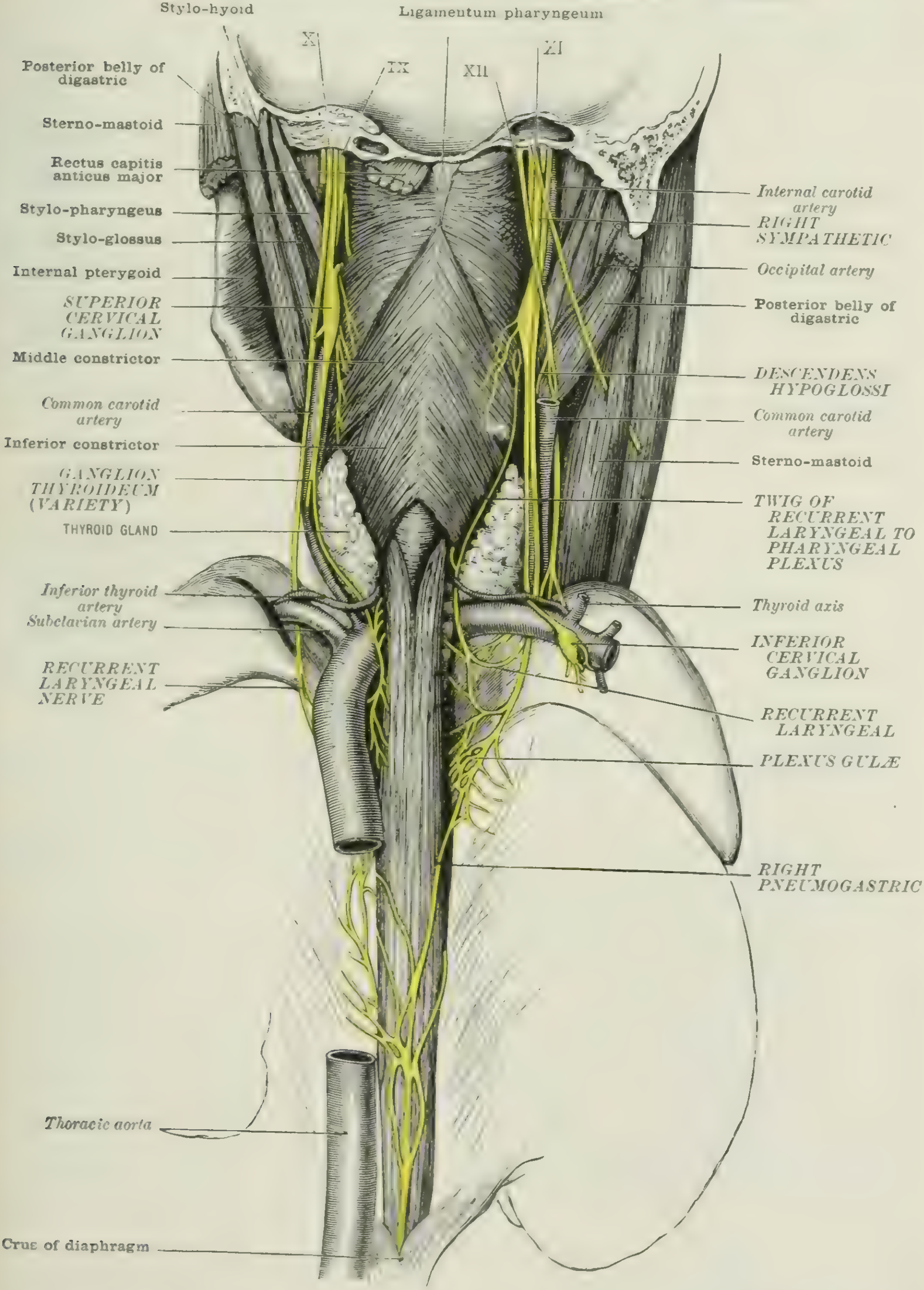
3. **Communicating branches to cranial nerves.**—Branches of communication arise directly from the ganglion to join the vagus, glosso-pharyngeal, and hypoglossal nerves. Communications are effected with the ganglia of the root and trunk of the vagus, and with the jugular and petrous ganglia of the glosso-pharyngeal.

4. The **pharyngeal branches,** four or five in number, pass downwards and inwards behind the external and internal carotid arteries to join the pharyngeal plexus.

5. The **superior cervical cardiac nerve** arises from the lower part of the ganglion, or occasionally from the nerve-cord between the superior and middle cervical ganglia. The nerves of the two sides run a corresponding course in the neck, but differ in their arrangement in the thorax. In the neck, each nerve is directed downwards on the prevertebral fascia in front of the longus colli muscle,

and communicates with the upper cervical cardiac branch of the pneumogastric, with the middle cardiac nerve of the sympathetic, and with the external laryngeal and recurrent laryngeal nerves.

FIG. 470.—THE CERVICAL PORTION OF THE SYMPATHETIC AND THE DISTRIBUTION OF THE PNEUMOGASTRIC NERVE, VIEWED FROM BEHIND. (Krause.)


Stylo-hyoid
Ligamentum pharyngeum
X
IX
XII
XI
Posterior belly of digastric
Sterno-mastoid
Rectus capitis anticus major
Stylo-pharyngeus
Stylo-glossus
Internal pterygoid
SUPERIOR CERVICAL GANGLION
Middle constrictor
Common carotid artery
Inferior constrictor
GANGLION THYROIDEUM (VARIETY)
THYROID GLAND
Inferior thyroid artery
Subclavian artery
RECURRENT LARYNGEAL NERVE
Thoracic aorta
Crus of diaphragm
Internal carotid artery
RIGHT SYMPATHETIC
Occipital artery
Posterior belly of digastric
DESCENDENS HYPOGLOSSI
Common carotid artery
Sterno-mastoid
TWIG OF RECURRENT LARYNGEAL TO PHARYNGEAL PLEXUS
Thyroid axis
INFERIOR CERVICAL GANGLION
RECURRENT LARYNGEAL
PLEXUS GULÆ
RIGHT PNEUMOGASTRIC

On the **right side** the nerve passes in front of (occasionally behind) the subclavian artery, and is directed along the innominate artery to reach the bifurcation of the trachea, in front of which it terminates in the deep cardiac plexus.

On the **left side** the nerve is conducted into the thorax in front of the common carotid artery, and crosses in front (or rather to the left side) of the arch of the aorta in the interval between the trunk of the vagus and its inferior cervical cardiac branch, and ends in the superficial cardiac plexus.

Middle Cervical Ganglion

The **middle cervical ganglion** is a small, somewhat triangular, ganglionic thickening of the cord of the sympathetic. It is situated at the point where the cord crosses the inferior thyroid artery at the level of the sixth cervical vertebra. It gives grey **rami communicantes** to the fifth and sixth cervical nerves. It is connected below to the inferior cervical ganglion by the main cord of the sympathetic, which passes behind the subclavian artery, and by one or more nerve-cords which pass in front of that vessel, forming the **ansa Vieussenii.** The middle cervical ganglion gives off branches to the thyroid body and the middle cardiac nerve.

The **branches to the thyroid body** communicate with the superior cardiac nerve, and proceed to the gland, following the branches of the inferior thyroid artery.

The **middle cardiac nerve** enters the thorax, passing sometimes in front of the subclavian artery, and sometimes behind that vessel. It communicates in the neck with the upper cardiac nerve, and in the thorax with the recurrent laryngeal. It terminates in the deep cardiac plexus. On the left side this nerve passes down between the left carotid and subclavian arteries.

Inferior Cervical Ganglion

The **inferior cervical ganglion** is larger than the middle ganglion, and is connected by short grey **rami communicantes** to the seventh and eighth cervical nerves. It is irregular in form and is deeply placed, being lodged in a depression between the neck of the first rib and the transverse process of the seventh cervical vertebra. In this situation it is concealed by the vertebral artery, the vessel being placed in front of the ganglion. It is united to the first thoracic ganglion by one or two stout cords and often by a band of ganglionic substance. It gives off branches to the vertebral artery and the inferior cardiac nerve.

The **branches to the vertebral artery** are of considerable size and accompany the vessel into the arterio-vertebral foramina in the transverse processes. The plexus thus formed is continued on the vertebral and basilar to the cerebral arteries.

The **inferior cardiac nerve** communicates with the middle cardiac and recurrent laryngeal, and passes along the side of the trachea to join the deep cardiac plexus. It occasionally arises from the first dorsal ganglion.

The majority, if not all, of the medullated fibres of the cervical part of the sympathetic cord enter it from the dorsal part, to which they pass by the white rami from the upper dorsal nerves. The destination of many of these fibres is unknown, but some terminate in ramifications round the cells of the upper cervical ganglion and others in a similar manner round the cells of the middle and lower ganglia. The fibres which terminate in the upper ganglion are the vaso-motor fibres of the head, the secretory fibres of the submaxillary glands, the dilator fibres of the pupil, the motor fibres for the smooth muscle of the eyelids and orbit, and the pilo-motor fibres (to the muscles of the hairs) of the face and neck. Those which terminate in the middle and lower cervical ganglia are the cardiac accelerator fibres, and possibly some of the secretory fibres of the sweat glands of the upper extremity.

THORACIC PORTION OF THE GANGLIATED CORD

The **thoracic portion of the gangliated cord** is represented by a chain of twelve pairs of ganglia. In a few cases, on account of the coalescence of some of the members of the series, the number may be reduced to eleven or ten pairs. The upper ten ganglia lie upon the heads of the corresponding ribs, immediately under cover of the pleura. The lower two are placed further forwards, and lie on the sides of the bodies of the eleventh and twelfth thoracic vertebræ between the bones and the diaphragm. The cord is continuous above with the cervical part of the cord, the first thoracic ganglion being sometimes united across the neck of the first rib with the inferior cervical ganglion. Below, the cord enters the abdominal cavity by passing behind the ligamentum arcuatum internum to become continuous with the lumbar part of the cord. The first thoracic ganglion (**ganglion stellatum**) is larger than the others, and is of an irregular form. The remainder of the series are triangular in outline, two of the angles being continued into the interganglionic part of the cord, and the other into the rami communicantes. On some of the lower ganglia a fourth angle makes its appearance, and is continued into one of the roots of the splanchnic nerves.

Branches.—The branches are classified into external and internal. The **external branches** are the rami communicantes. A grey and a white ramus communicans connects each ganglion with the corresponding thoracic nerve. The **internal branches** are the rami efferentes, those **of the upper four ganglia** are distributed chiefly to the aorta and lungs. The **internal branches of the lower eight ganglia** form three splanchnic nerves which are distributed to the abdominal viscera.

Internal branches.—Upper series.—From the upper four or five ganglia fine twigs arise which are distributed to the thoracic aorta, mediastinum, lungs, vertebræ, and ligaments.

Internal branches.—Lower series.—These branches, although arising in the thorax, are destined for the abdominal viscera. The branches from the fifth to the ninth ganglia unite to form the great splanchnic nerve; the lesser splanchnic nerve arises by two roots from the tenth and eleventh ganglia, while the internal branch of the twelfth ganglion forms the smallest splanchnic nerve.

GREAT SPLANCHNIC NERVE.—The five roots of this nerve run downwards and inwards, between the pleura and the bodies of the thoracic vertebræ, and unite within the posterior mediastinum to form a trunk of considerable size. The nerve thus formed pierces the crus of the diaphragm, and enters the semilunar ganglion of its own side.

The great splanchnic nerve is whitish in colour, owing to a number of medullated fibres entering into its composition. Occasionally a small ganglion (splanchnic ganglion) is developed upon it in the mediastinum. This ganglion is constant on the right side. (Cunningham.)

The **LESSER SPLANCHNIC NERVE** runs a similar course to the great splanchnic, but at a lower level. It pierces the crus of the diaphragm, or passes through the internal arcuate ligament, and enters the solar and renal plexuses.

The **SMALLEST SPLANCHNIC NERVE** passes behind the internal arcuate ligament or through the crus of the diaphragm and enters the renal plexus.

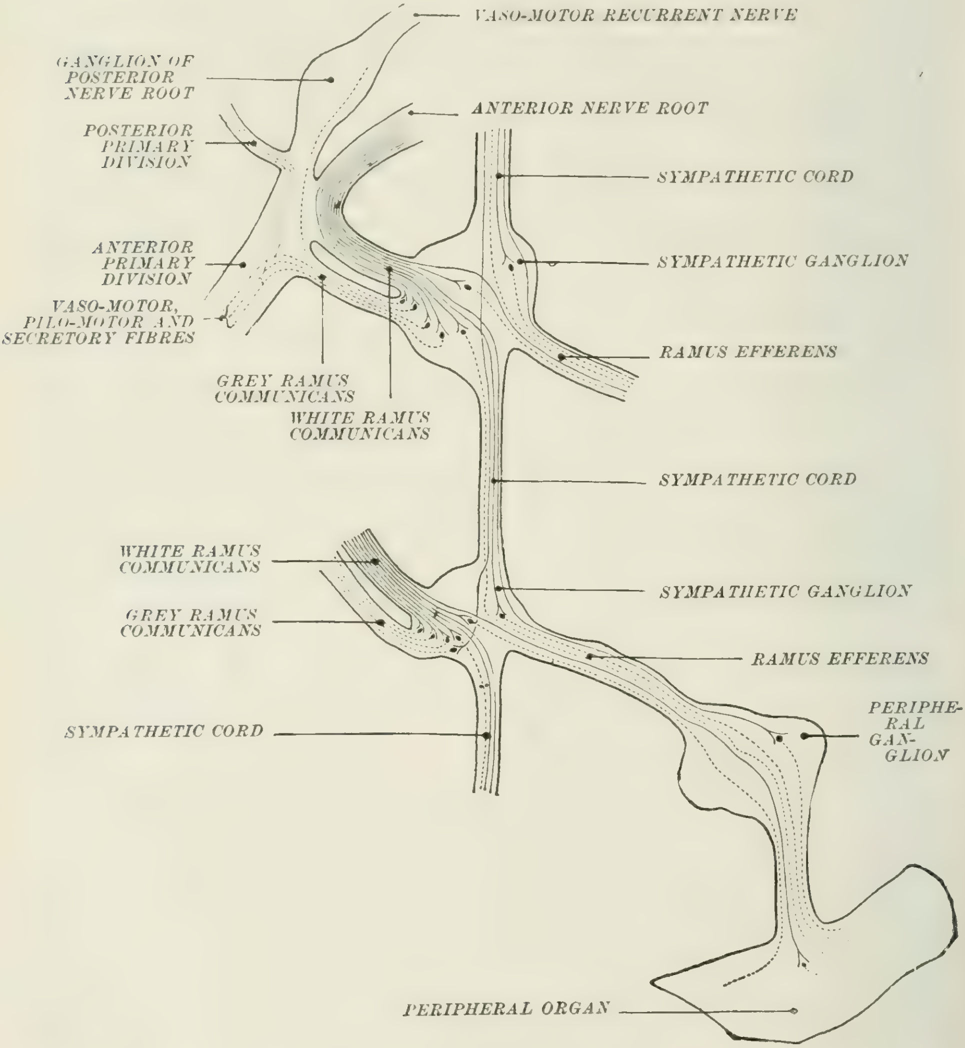
The majority of the sympathetic fibres which pass from the central nervous system enter the dorsal part of the sympathetic chain; some end there, in ramifications around the cells of the ganglia, and others merely pass through on their way to more distant terminations. With regard to those which terminate in the ganglia it has been shown that in the dog and cat many end in the ganglion stellatum, which corresponds with the last cervical and the upper three or four dorsal ganglia in man: amongst these are the secretory fibres to the sweat glands of the upper limb which emerge from the spinal cord by the dorsal nerves from the sixth to the ninth, and, in the dog, vaso-constrictor fibres of the pulmonary blood-vessels which leave the spinal cord by the second to the seventh dorsal nerves. Other fibres which terminate around the thoracic ganglion cells in the dog and the cat are the vaso-constrictor fibres of the upper limbs and some of the vaso-constrictor fibres of the lower limb.

Of the fibres which traverse the dorsal part of the sympathetic cord, to gain more distant terminations, some ascend to the cervical region (p. 830), others descend to the lumbar region, and many pass by the rami efferentes to the splanchnic nerves.

Amongst those which descend to the lumbar region are pilo-motor fibres, vaso-motor fibres, and secretory fibres to the lower limb, some vaso-constrictor fibres to the abdominal blood-vessels, motor fibres to the circular, and inhibitory fibres to the longitudinal muscle of the rectum: the latter enter the sympathetic cord by the lower dorsal nerves, they pass by the lumbar efferentes to the aortic plexus and terminate round the cells of the inferior mesenteric ganglion.

The fibres which pass through the dorsal ganglia to the splanchnic nerves are

FIG. 470A.


VASO-MOTOR RECURRENT NERVE
GANGLION OF POSTERIOR NERVE ROOT
ANTERIOR NERVE ROOT
POSTERIOR PRIMARY DIVISION
SYMPATHETIC CORD
ANTERIOR PRIMARY DIVISION
SYMPATHETIC GANGLION
VASO-MOTOR, PILO-MOTOR AND SECRETORY FIBRES
RAMUS EFFERENS
GREY RAMUS COMMUNICANS
WHITE RAMUS COMMUNICANS
SYMPATHETIC CORD
WHITE RAMUS COMMUNICANS
SYMPATHETIC GANGLION
GREY RAMUS COMMUNICANS
RAMUS EFFERENS
PERIPHERAL GANGLION
SYMPATHETIC CORD
PERIPHERAL ORGAN

mainly vaso-motor fibres to the abdominal blood-vessels, the majority of them probably terminate around the cells of the ganglia in the solar plexus, but those for the renal blood-vessels are said to end in the renal ganglia. In addition to all the above-mentioned fibres there are, in the dorsal part of the sympathetic cord afferent (splanchnic sensory) fibres, passing towards the posterior roots of the dorsal nerves.

LUMBAR PORTION OF THE GANGLIATED CORD

The **lumbar part of the gangliated cord** consists of a chain of ganglia, usually four in number, which are placed in front of the bodies of the vertebræ, close to the anterior border of the psoas muscle. On the right side the cord is covered by the vena cava, and on the left side it is behind and external to the aorta. Above, it is continuous with the thoracic part of the cord. Below, it is continued into the sacral part of the cord by passing behind the common iliac vessels. The **rami communicantes** are longer in this part of the gangliated cord than in any other region of the body. Usually two rami pass from each ganglion backwards through the fibrous arches from which the psoas takes origin, and join the lumbar nerves in a somewhat variable manner. Frequently there is only one ramus communicans and sometimes the number of rami is increased. The rami communicantes are accompanied by the lumbar arteries.

Branches.—Some of the branches join the aortic plexus; others pass in front of the common iliac arteries to form the hypogastric plexus, and some terminate in the vertebræ and ligaments.

The lumbar portion of the sympathetic cord contains a number of fibres already described (p. 831) which have descended to it from the dorsal region, but it also obtains others by the white rami from the lumbar nerves; amongst the latter are additional vaso-constrictor fibres for the renal blood-vessels, secretory fibres for the glands of the hind limb, constrictor fibres for the blood-vessels of the lower extremity, pilo-motor fibres, motor fibres for the circular, and inhibitory fibres for the longitudinal muscle of the rectum, motor fibres for the uterus, vas deferens and round ligament, motor fibres for the circular and inhibitory fibres for the longitudinal fibres of the bladder, and vaso-motor fibres for the penis.

The motor fibres for the bladder and uterus leave the lumbar sympathetic cord by the rami efferentes and pass by the aortic plexus to the inferior mesenteric ganglion. The motor fibres to the vas deferens and spermatic cord enter the genitocrural nerve. Of the vaso-motor fibres of the penis some of the constrictor fibres pass down to the sacral portion of the sympathetic cord where they ramify round the cells of the sacral ganglia, the impulses they carry being transmitted by the grey rami of the sacral ganglia to the pudic nerve. Others travel by the inferior mesenteric ganglion, and the latter are accompanied by the vaso-dilator fibres of the penis.

SACRAL PORTION OF THE GANGLIATED CORD

The **sacral part of the gangliated cord** consists of a chain of four small ganglia, which is placed in front of the sacrum internal to the anterior sacral foramina. From the lowest of these ganglia, branches proceed on each side and converge to a median ganglion (**ganglion impar**) which is situated in front of the last piece of the sacrum or the first piece of the coccyx. The sacral ganglia are connected in a somewhat irregular manner to the sacral nerves by short grey **rami communicantes.**

Branches.—From the upper sacral ganglia branches are given off which join the pelvic plexuses. Others pass across the sacrum to join corresponding branches from the cord of the opposite side. From the **ganglion impar** twigs pass downwards to enter the coccygeal body.

There are no white rami from the sacral nerves to the sacral sympathetic ganglia, therefore all the medullated fibres contained in the sacral sympathetic cord have descended to it from the dorsal and lumbar regions. They include some vaso-constrictor and secretory fibres for the hind limb, pilo-motor fibres for the posterior part of the body, including, in the cat, the tail, and some vaso-constrictor fibres of the penis.

The white rami of the sacral nerves are represented by their visceral branches, the so-called pelvic splanchnics. These contain motor fibres to the longitudinal muscle of the bladder, motor fibres for the longitudinal and inhibitory fibres for the circular muscle of the rectum, motor fibres for the uterus, secretory fibres for the prostate gland, and vaso-dilator fibres for the penis.

THE GREAT PREVERTEBRAL PLEXUSES

The **great prevertebral plexuses,** as we have already noticed, are the cardiac, solar, and hypogastric. They are formed mainly by branches derived from the gangliated cords, but also receive fibres from the cerebro-spinal nerves; thus the cardiac plexus and solar plexuses are joined by branches of the pneumogastric, and the hypogastric plexus is joined by branches of the third and fourth and sometimes the second sacral nerves.

CARDIAC PLEXUS

As already noted, each pneumogastric nerve gives off two or three cervical cardiac branches, a thoracic cardiac branch, and additional branches may spring from the recurrent laryngeal nerve. There are also three cardiac nerves which arise from the cervical sympathetic cord on each side. These nerves all proceed to the cardiac plexus, but their course and arrangement is extremely variable. It is very common to find the upper cervical cardiac branches of the vagus and sympathetic uniting to form a common trunk; in other cases the nerves branch and communicate with one another in a plexiform manner. The cardiac plexus, although forming a continuous network of nerves, is for convenience divided into a superficial and a deep plexus. The **superficial plexus** is situated immediately below the arch of the aorta, internal to the ligamentum ductus arteriosus: it receives the left superior cardiac nerve of the sympathetic and the left inferior cervical cardiac branch of the pneumogastric. The **deep cardiac plexus** is placed in front of the bifurcation of the trachea between that structure and the aortic arch; it receives all the other cardiac nerves.

Superficial cardiac plexus.—The superior cardiac branch of the sympathetic and the inferior cervical cardiac branch of the vagus cross the aortic arch on its left side, being placed between the artery and the left pleura. The nerves then enter the interval between the aortic arch and the bifurcation of the pulmonary artery, where they communicate with the deep cardiac plexus. A small ganglion (the cardiac ganglion of Wrisberg) is usually developed at the point of communication. Branches are furnished to the right coronary plexus and also to the left lung. The latter branches join the anterior pulmonary plexus.

Deep cardiac plexus.—The deep cardiac plexus receives all the right cardiac nerves, and also the cardiac nerves of the left side, with the exception of the superior cervical cardiac of the sympathetic and the inferior cervical cardiac of the vagus. The plexus is placed in front of the bifurcation of the trachea, and gives off the following branches:—(*a*) Branches to the anterior pulmonary plexuses of both sides; (*b*) the left coronary plexus; (*c*) branches to the right auricle; (*d*) communicating branches to the superficial cardiac plexus; and (*e*) branches to the right coronary plexus.

Right coronary plexus.—This plexus is formed by branches from both the superficial and deep cardiac plexuses. It follows the branches of the right coronary artery for a certain distance, beyond which the nerves diverge from the arteries, and run between the pericardium and the muscular substance of the heart. Finally they enter the muscular substance.

Left coronary plexus.—This plexus is larger than the right. It arises from the deep cardiac plexus, passes forwards between the left auricular appendix and the pulmonary artery, and accompanies the branches of the left coronary artery.

The auricles are supplied by the lower, and the ventricles, pulmonary artery and aorta by the upper cardiac nerves.

The cardiac plexuses and the network of nervous structures in the walls of the auricles are the remains of the primitive plexuses found in the embryo which are called the bulbar, the intermediate, and the atrial plexuses, terms which sufficiently indicate their relative positions. The bulbar plexus gives off the coronary nerves and is transformed into the superficial and part of the deep cardiac plexus; the remainder of the deep cardiac plexus is formed by the intermediate plexus and the atrial plexus becomes the auricular network.

The fibres which pass to the cardiac plexuses are medullated and non-medullated: the former are inhibitory, the latter motor. The inhibitory fibres leave the central nervous system by the spinal accessory and vagus nerves, the motor fibres by the roots of the dorsal nerves.

SOLAR PLEXUS

The **solar plexus** is placed in front of the commencement of the abdominal aorta. It is the largest of the prevertebral plexuses, and is formed by the two semilunar ganglia, and by a number of interlacing nerve-cords which surround the ganglia. Each semilunar ganglion is placed at the side of the cœliac axis, embracing the artery in its concavity. The upper and the lower extremities of the ganglia of opposite sides are connected to one another by nerve-cords, above and below the artery. In this manner the cœliac axis is surrounded by a neuro-ganglionic collar. From this neuro-ganglionic collar a number of branches arise which are joined by branches from the right vagus and by both small splanchnic nerves, and in this manner the solar plexus is formed. From the solar plexus a number of nerves arise which accompany the abdominal aorta and its branches, forming secondary plexuses, which take their names from the arteries they accompany.

Semilunar ganglia.—These are a pair of reddish-grey, irregularly shaped bodies which rest on the crura of the diaphragm, close to the cœliac axis. The great splanchnic nerve on each side, after piercing the crus of the diaphragm, enters the outer, or convex, side of the corresponding ganglion.

Cœliac plexus.—The cœliac plexus surrounds the cœliac axis, and divides into splenic, hepatic, and coronary plexuses.

The **splenic plexus**, after receiving a communication from the right pneumogastric nerve, accompanies the splenic artery to the spleen. It gives off pancreatic and left gastro-epiploic plexuses.

The **hepatic plexus** is joined, near the pyloric end of the stomach, by branches from the left pneumogastric, and accompanies the hepatic artery to the liver, where it divides into right and left hepatic plexuses. Previous to its division, it gives off **pyloric, right gastro-epiploic,** and **pancreatico-duodenal plexuses.** From the right hepatic plexus a **cystic** plexus is furnished to the gall-bladder.

The **coronary plexus** follows the lesser curvature of the stomach, proceeding from left to right. In this course it is joined by branches from the left pneumogastric, and, after giving off numerous twigs to the stomach, ends, near the pylorus, by joining the pyloric plexus.

The **diaphragmatic plexuses** arise from the upper extremities of the semilunar ganglia, and accompany the diaphragmatic arteries to the under surface of the diaphragm. On the right side a communication is effected with the phrenic nerve, a small ganglion (**ganglion diaphragmaticum**) being formed at the point of communication.

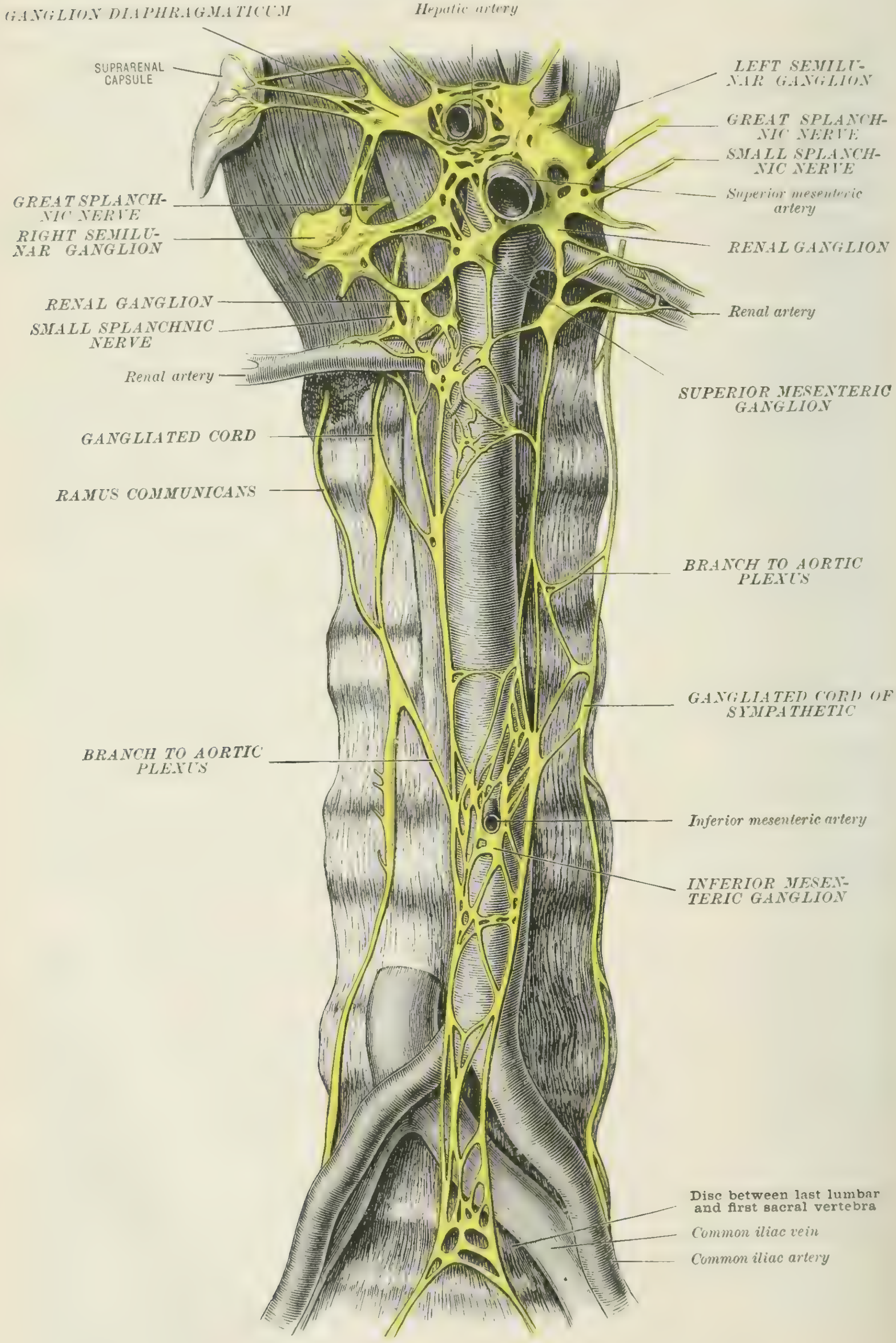
The **suprarenal plexuses** are derived, in part from the diaphragmatic, in part from the solar, and in part from the renal plexuses; they are distributed chiefly to the medullary portions of the suprarenal bodies.

The **renal plexuses** are formed by branches of the solar and aortic plexuses, and are joined posteriorly by the smallest splanchnic nerves. Each renal plexus surrounds the corresponding renal artery; it contains groups of ganglion cells and enters the hilum of the kidney, where it subdivides in the fatty tissue which occupies the sinus, and enters the substance of the kidney with the blood-vessels.

The **superior mesenteric plexus** is of large size, and is remarkable for the comparatively white colour of the nerves which compose it. It is derived from the solar plexus, and, after emerging from under cover of the pancreas, closely surrounds the trunk of the superior mesenteric artery. In this situation a few ganglia (**ganglia mesenterica**) are formed. Having given off branches, which accompany the colica media, colica dextra, and ileo-colic arteries, the greater part of the plexus enters the mesentery, where the nerves—no longer closely following the blood-vessels, spread out between the layers of the mesentery, and eventually reach the small intestine.

The **aortic plexus** is in the form of two vast networks of nerves which are

Fig. 471.—Lumbar Portion of the Gangliated Cord, with the Solar and Hypogastric Plexuses. (Henle.)


GANGLION DIAPHRAGMATICUM
Hepatic artery
SUPRARENAL CAPSULE
LEFT SEMILUNAR GANGLION
GREAT SPLANCHNIC NERVE
SMALL SPLANCHNIC NERVE
Superior mesenteric artery
GREAT SPLANCHNIC NERVE
RIGHT SEMILUNAR GANGLION
RENAL GANGLION
RENAL GANGLION
Renal artery
SMALL SPLANCHNIC NERVE
Renal artery
SUPERIOR MESENTERIC GANGLION
GANGLIATED CORD
RAMUS COMMUNICANS
BRANCH TO AORTIC PLEXUS
GANGLIATED CORD OF SYMPATHETIC
BRANCH TO AORTIC PLEXUS
Inferior mesenteric artery
INFERIOR MESENTERIC GANGLION
Disc between last lumbar and first sacral vertebra
Common iliac vein
Common iliac artery

massed along the sides of the abdominal aorta, and are connected by communicating branches which pass across the front of the great vessel. It is formed mainly by the downward continuation of the solar plexus, but receives strong reinforcements from the upper three lumbar ganglia. It gives off the spermatic and inferior mesenteric plexuses, and terminates below in strong branches to the hypogastric plexus.

The **inferior mesenteric plexus** is much smaller than the superior mesenteric plexus, but, like the latter, is remarkable for its whitish colour. It is derived from the aortic plexus, and is conveyed by the branches of the inferior mesenteric artery to the descending colon, the sigmoid flexure, and to the upper part of the rectum. In the latter situation it communicates with the pelvic plexuses. It contains the inferior mesenteric ganglion.

The **spermatic plexus** is derived from the aortic and renal plexuses. It accompanies the spermatic artery as far as the internal abdominal ring, where it is joined by a fine plexus derived from the pelvic plexus and accompanying the vas deferens. Thus reinforced, it is conducted by the spermatic cord to the testicle.

In the female it accompanies the ovarian vessels to the ovary and uterus.

The more important fibres which pass to the solar plexus have already been described in connection with the lumbar and dorsal portions of the sympathetic cord.

HYPOGASTRIC PLEXUS

From the lower ganglia of the lumbar sympathetic cord, two or three strong branches proceed which cross obliquely in front of the common iliac arteries. These nerves are joined by stout offsets from the aortic plexus, and interlace in front of the body of the fifth lumbar vertebra with the corresponding nerves of the opposite side to form a broad flattened band, which is termed the hypogastric plexus. This plexus is remarkable in that it contains little or no ganglionic matter. It soon divides into two lateral portions, the pelvic or inferior hypogastric plexuses.

Pelvic Plexuses

Each of the two lateral continuations of the hypogastric plexus contains ganglion cells; it passes downwards on the side of the rectum, where it is joined by slender branches from the sacral part of the gangliated cord, and by branches from the third and fourth (sometimes the second) sacral nerves. In this manner the pelvic plexuses are formed. Each pelvic plexus gives off branches to the pelvic viscera; these branches, in the greater part of their course, follow the arteries of the pelvis. We distinguish middle hæmorrhoidal, vesical, prostatic, and (in the female) vaginal and uterine plexuses.

The **middle hæmorrhoidal plexuses** form a closely-meshed expansion on the sides of the rectum; they communicate above with branches from the inferior mesenteric plexus, and below with the inferior hæmorrhoidal branches of the pudic nerve.

The **vesical plexus** is chiefly formed by fibres derived from the third and fourth sacral nerves. The nerves pass forwards on each side of the bladder, and divide into two groups—a **superior group**, which supplies the upper two-thirds of the bladder; and an **inferior group**, which is distributed to the lower third of that viscus. In the male, branches are given off to the vesiculæ seminales and vasa deferentia. The **nerves to the vas deferens** form a slender plexus which accompanies that structure as far as the internal abdominal ring, where it unites with the spermatic plexus.

The **prostatic plexus** is placed a little lower down than the vesical plexus, of which it is in some measure a continuation. The nerves which pass to it are of relatively large size, and are massed on the sides of the organ, where several ganglionic masses, from one-eighth to a quarter of an inch in length (**ganglia prostatica** of Müller), are developed. From the prostatic plexus, offsets are furnished to the vesiculæ seminales, and also branches to the erectile structures of the penis; the latter branches are called cavernous nerves.

The **small cavernous nerves** are several fine twigs which pierce the layers of the triangular ligament and the muscular structures which surround the membranous portion of the urethra. They enter the corpora cavernosa just in front of the subpubic ligament.

The **large cavernous nerve** takes a similar course through the triangular ligament, and runs forwards on the dorsum penis as far as the middle of the organ, where it communicates with the dorsal nerves of the penis. It ends in twigs to the corpus cavernosum.

In the female there are similar nerves, but of much smaller size, distributed to the clitoris.

The **vaginal plexus** is formed largely by branches from the sacral nerves. It ramifies on the sides of the vagina, giving off twigs to the erectile substance, and to the mucous membrane. A few fine twigs pass forwards to reach the clitoris.

The **uterine plexus** accompanies the uterine artery between the layers of the broad ligament, and, having received communicating twigs from the ovarian plexus, enters the muscular substance. In the gravid uterus this plexus is increased in size, chiefly on account of an hypertrophy of the connective tissue sheaths of the nerves.

The more important fibres passing to the pelvic plexuses are described with the visceral branches of the sacral plexus.

SECTION VI

ORGANS OF SPECIAL SENSE

THE EYE

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THE EYEBALL AND ITS SURROUNDINGS

General Surface View

This examination is to be made prior to any disturbance of the parts, and is, indeed, best conducted on the living body. A pocket magnifying lens should be at hand for use when required.

THE two eyes are situated nearly in the line where the upper and middle thirds of the face meet; they lie right and left of the root of the nose, the most prominent part of the front of each globe being about an inch and a quarter from the middle line of the face. Each eye is overshadowed by the corresponding eyebrow, and is capable of being concealed by its eyelids, upper and lower.

The orbital margin may be traced all round with the finger. At the junction of the inner and middle thirds of the upper margin, the supraorbital notch can usually be felt, and the supraorbital nerve passing through it can sometimes be made to roll from side to side under the finger. The inner margin is the most difficult to trace in this way, partly because it is more rounded off than the others, partly because it is bridged over by a firm fibrous band (**tendo oculi,** or **inner palpebral ligament**), passing inwards from the eyelids; below this band, however, a sharp bony crest is felt, which lies in front of the lachrymal sac. Note how the eye is protected by the rim of the orbit, above and below; if we lay a hard flat body over the orbital opening, it will rest upon the upper and lower bony prominences, and will not touch the surface of the globe. Inwards, the eye is protected from injury mainly by the bridge of the nose; outwards it is most readily vulnerable, as here the orbital rim is comparatively low. With one finger placed over the closed upper lid, now press the eyeball gently backwards into the orbit, and observe the elastic resistance met with, due to the fact that the globe rests posteriorly on a pad of fat.

The space between the free edges of the upper and lower lids is known as the **palpebral aperture**: it is a mere slit when the lids are closed; but when they are open its shape is, roughly, that of an almond lying with its long axis horizontal, and about thirty millimetres in length.

When the eyes are directed to an object straight in front of them, this aperture is about twelve millimetres wide, but its width varies with upward and downward movements of the eyeball, being greatest on looking strongly upwards, diminishing gradually as the eye looks progressively lower. The angles formed by the meeting of the lids at each end of the palpebral aperture are named respectively the **outer** and **inner canthus,** of which the outer, or temporal, is sharp, while the inner, or nasal, is rounded off. On a closer inspection, it will be found that, for the last five millimetres or so before reaching the inner canthus, the edges of the lids run an almost parallel course, and are here devoid of lashes. Through the open palpebral aperture the front of the eyeball comes into view, extending quite to the outer, but not reaching as far as the inner, canthus; just within the latter we find a small reddish prominence, the **lachrymal caruncle** ; and between this and the eyeball a fold of conjunctiva known as the **plica semilunaris.** While the eye is open, press one finger on the skin, a little beyond the outer canthus, and draw it firmly outwards from the middle line; observe that the upper lid then falls over the eyeball, and that the outline of a firm band already referred to (the tendo oculi) becomes evident, passing between the inner canthus and the nose. The falling of the lid is caused by our dragging upon a ligament (the outer palpebral) to which the outer end of its tarsus is attached, and so putting the lid itself upon the stretch. If, while the eyeball is directed downwards, we place one finger on the outer end of the upper eyelid and draw it forcibly upwards and outwards, we can usually cause the lower division of the lachrymal gland to present just above the outer canthus.

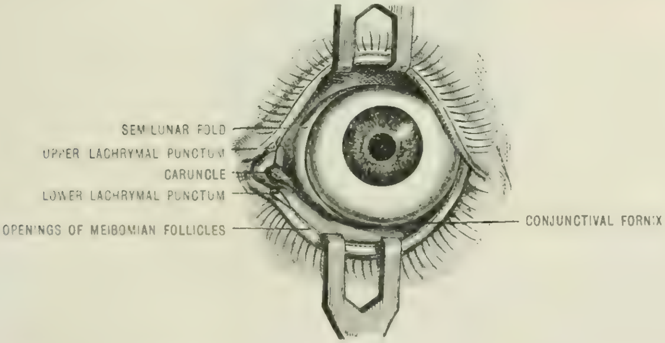
The **upper eyelid** is much broader than the lower, extending upwards as far as the eyebrow. The skin covering it is loosely attached to the subjacent tissues above, but more firmly below, nearer the free margin, where it overlies a firm fibrous tissue called the **tarsus.** When the eye is open, a fold is present at the upper border of this latter more tightly applied portion of skin, called the **superior palpebral fold,** and by it the lid is marked off into an upper or orbital, and a lower or tarsal, division. The presence of the tarsus can be readily appreciated on our pinching horizontally the entire thickness of the eyelid below the palpebral fold. The **lower eyelid** is similarly divided anatomically into a tarsal and an orbital part, but the demarcation is sometimes unrecognisable on the surface, though there is usually here also a fold or groove (the **inferior palpebral**) visible when the eye is widely opened. There is no precise limit of this lid below, but it may be regarded as extending to the level of the lower margin of the orbit. Numerous very fine short hairs are seen on the cutaneous surface of both eyelids. The free margin of each lid has two edges—(*a*) An outer, or anterior, rounded edge, along which the stiff eyelashes, or cilia, are closely placed in several rows; and (*b*) a sharp posterior edge, which is applied to the surface of the globe. The lashes of both eyelids have their points turned away from the palpebral aperture, so that the upper ones curve upwards, and the lower downwards; the cilia of the upper lid are the stronger, and those in the middle of each row are longer than those at each end. Between the two edges just described, the lid-margin has a smooth surface, on which we observe a single row of minute apertures, which are the openings of large modified sebaceous glands (the **Meibomian follicles**) ; it is by these glistening, well-lubricated surfaces that the opposite lids come into apposition when they are closed. The sharp posterior edge of the lid-margin marks the situation of the transition of skin into mucous membrane. Not far from the inner end of this edge we find a prominence, the **lachrymal papilla,** on the summit of which is a small hole (**lachrymal punctum**), the opening of the canaliculus for the passage of tears into the lachrymal sac. The lower punctum is rather larger than the upper, and is placed further from the inner canthus.

If we now examine the inner surface of the eyelids—e.g. of the lower—we observe that it is lined by a soft mucous membrane, the **palpebral conjunctiva.** Over the tarsal part of the lid, the conjunctiva is closely adherent, but beyond this it is freely movable along with the loose submucous tissue here present. On tracing it backwards, we find that it covers the whole inner surface of the lids, and is then continued *forwards* over the front of the eyeball, forming the ocular conjunctiva; the bend it makes as it changes its direction here is called the conjunctival *cul-de-sac*, or **fornix.** Numerous underlying blood-vessels are visible through the palpebral conjunctiva, and beneath the tarsal part of it we can see a series of nearly straight, parallel, light yellow lines, arranged perpendicularly to the free margin of the lid—the Meibomian follicles. The conjunctiva over the outer and inner fourths of each lid is not quite so smooth as elsewhere, and is normally of a deeper red colour; we shall find later that there are glands well developed in these positions.

When the eyelids are opened naturally, we see through the palpebral aperture the following: the greater part of the transparent cornea, and behind it the coloured iris with the pupil in its centre; white sclerotic to the outer and inner sides of the cornea; the semilunar fold and lachrymal caruncle at the inner canthus. The extent of the eyeball visible in this way varies according to its position. Thus, with the eyes looking straight forwards, the lower margin of the upper lid is nearly opposite to the top of the cornea, or, more strictly, to a line midway between the top of the cornea and the upper border of the pupil, while the lower lid corresponds with the lower corneal margin. When the eyes are directed strongly upwards, the upper lid is relatively on a slightly higher level, as it is simultaneously raised, but the lower lid now leaves a strip of sclerotic exposed below the cornea. On looking downwards the upper lid covers the upper part of the cornea as low down as the level of the top of the pupil, while the lower lid is about midway between the pupil and the lower corneal border.

If we draw the eyelids forcibly apart, we expose the whole cornea, and a zone of sclerotic about eight and a half millimetres in breadth above and below, and ten millimetres in breadth to the outer and inner sides, altogether about one-third of the globe; all the eyeball thus exposed is covered by the **ocular conjunctiva.** Over the sclerotic the conjunctiva is freely movable, and through it we see superficial blood-vessels that can be made to slip from side to side along with it (conjunctival vessels). Occasionally other deeper vessels may also be seen which do not move with the conjunctiva, but are attached to the sclerotic (anterior ciliary arteries and veins). Near the corneal border the conjunctiva ceases to be freely movable, and it is closely adherent to the whole anterior surface of the cornea, giving the latter its characteristic bright, reflecting appearance; no blood-vessels are visible through it here in health. (When the lids are shut, the space enclosed between their posterior surfaces and the front of the eyeball is thus everywhere covered by conjunctiva, and is known as the **conjunctival sac.**)

FIG. 472.—VIEW OF EYEBALL, ETC., OBTAINED ON DRAWING THE LIDS FORCIBLY APART. (After Merkel, slightly modified.)

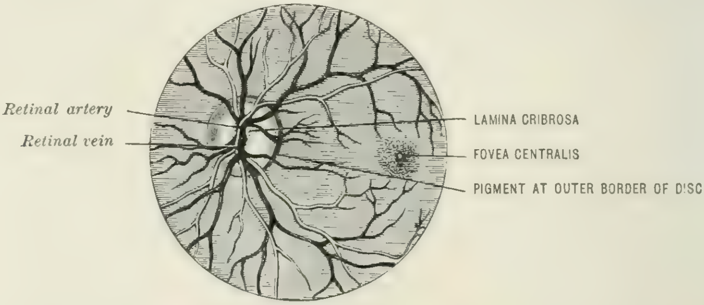


Not infrequently, the tendinous insertions of some or all of the recti muscles into the sclerotic may be seen through the conjunctiva, each insertion appearing as a series of whitish parallel lines running towards, but terminating about seven millimetres from the corresponding corneal border. The cornea appears as a transparent dome, having a curvature greater than that of the sclerotic; the junction of the two unequally curved surfaces is marked by a shallow depression running around the cornea, known as the **scleral sulcus.** In outline the cornea is nearly circular, but its horizontal diameter is slightly greater than its vertical. Between it and the iris a space exists, whose depth we can estimate roughly by looking at the eye from one side; this space, or anterior chamber, is occupied by a clear fluid, the aqueous humour. Almost the whole anterior surface of the iris is visible, its extreme periphery only being concealed by sclerotic. In colour the iris varies greatly in different individuals. Near its centre (really a little up and in) a round hole exists in the iris, the black *pupil*, whose size varies considerably in different eyes, and in the same eye according to temporary conditions, such as exposure to light, etc.

In examining the surface-markings of the living iris, one of dark colour is to be preferred. Focal illumination will be found useful, for which purpose a second convex lens will be required.

On the surface of the iris we see a number of ridges running more or less radially; adjoining ones occasionally unite and interlace to some extent, so as to leave large depressed meshes at intervals. The ridges coming from the edge of the pupil, and those coming from the more peripheral part of the iris, meet in a zigzag elevated ridge, concentric with the pupil, and by this ridge the iris is roughly marked off into two unequal zones—an outer or **ciliary,** and an inner or **pupillary**—of which the inner is much the narrower. The border next the pupil is edged with small, roundish, bead-like prominences of a dark brown colour, separated from one another by depressions, so that it presents a finely notched contour. Not infrequently, in a light-coloured iris, we may see the sphincter muscle through the anterior layers, in the form of a ring about one millimetre in breadth around the pupil. The ciliary zone may be described as consisting of three parts: (*a*) A comparatively smooth zone next the zigzag ridge; (*b*) a middle area, showing concentric but incompletely circular furrows; (*c*) a small peripheral darker part, presenting a sieve-like appearance. On the floor of the large depressed meshes, or *crypts*, parallel radial vessels can be traced, belonging to the iris-stroma. The zigzag line mentioned above corresponds to the position of the circulus arteriosus minor. Occasionally, especially in a light iris, superficial pigment spots of a rusty brown colour occur.

FIG. 473.—LEFT FUNDUS OCULI, AS SEEN BY DIRECT OPHTHALMOSCOPIC METHOD.



If we are examining the living eye, the ophthalmoscope should now be used, so as to gain a view of the fundus. We can thus study the termination of the optic nerve, the distribution of the larger retinal vessels, etc.

The general red reflex obtained from the fundus is due to the blood in a capillary network (**chorio-capillaris**) situated in the inner part of the choroid. To the nasal side of the centre of the fundus is a paler area of a disc shape corresponding to the intraocular end of the optic nerve, and known as the **optic disc,** or **papilla.** This optic disc is nearly circular, but usually slightly oval vertically; it is of a light orange-pink colour, with a characteristic superficial translucency; its outer third segment is paler than the rest from the nerve-fibres and capillaries here being fewer. About its centre we often observe a well-marked whitish depression or gap, formed by the dispersion of the nerve-fibres as they spread out over the fundus; at the bottom of this depression a sieve-like appearance may be seen, due to the presence of the **lamina cribrosa,** which consists of a white fibrous tissue framework, with small, roundish, light-grey meshes in it, through which latter the nerve-fibre bundles pass. Also near the centre of the disc, the retinal blood-vessels first come into view, the arteries narrower in size and lighter in colour than the veins; they divide dichotomously as they are distributed over the fundus. The retina proper is so transparent as to be ophthalmoscopically invisible, but its pigment-epithelium gives a very finely granular or darkly stippled appearance to the general red reflex. In the centre of the fundus, and therefore to the outer side of the disc, the ophthalmoscope often shows a shifting halo of light playing round a horizontally oval, comparatively dark enclosed area; this latter corresponds to the **yellow spot** region, and about its centre a small pale spot usually marks the position of the **fovea centralis.**

Two structures visible at the nasal end of the palpebral aperture have been previously mentioned, and should now be examined more narrowly. The **lachrymal caruncle** is in reality an island of modified skin, and fine hairs can commonly be detected on its surface. On its outer side, separated from it by a narrow groove, is the **semilunar fold of conjunctiva**; it rests on the eyeball, and is a rudiment of the third eyelid or nictitating membrane, present in birds and well represented in many other vertebrates.

Examination of the Eyeball

The eyeball of a cadaver should now be removed by snipping with scissors the conjunctiva near the corneal border, then cutting through the ocular muscles near their insertion into the globe, and finally dividing the optic nerve close to the sclerotic.

The eyeball is almost spherical, but not perfectly so, mainly because its anterior, clear, or *corneal* segment has a greater curvature than the rest of the eye. Considering it as a globe, however, we speak of an **anterior** and of a **posterior pole**; the former corresponding to the middle of the front of the cornea, the latter to the middle of the posterior curvature. An imaginary straight line joining the two poles is called the antero-posterior or **sagittal axis** of the eyeball. The **equator** of the eye is that part of its surface which lies midway between the two poles. The sagittal axis of the globe is the greatest (about 24·5 mm.), the vertical equatorial the least (about 23·5 mm.), and the transverse equatorial axis is intermediate in length (about 23·9), so that the eyeball is in reality an ellipsoid, flattened slightly from above downwards. Again, if the globe is divided in its antero-posterior vertical plane, the nasal division will be found to be slightly smaller than the temporal. The optic nerve joins the globe three or four millimetres to the nasal side of the posterior pole.

The shape of the eye depends on, and is preserved by, the outermost tunic, formed conjointly by the cornea and sclerotic, the entire outer surfaces of which are now in view. The anterior or corneal part has been already examined. All round the cornea there remains a little adherent conjunctiva; elsewhere, the sclerotic is directly exposed, except for some loose connective tissue which adheres to it, especially around the optic nerve entrance. In front of the equator we see the tendinous insertions of the four recti muscles. Behind the equator are the insertions of the two oblique muscles—that of the superior oblique tendinous, and further forwards; that of the inferior more fleshy, and placed between the optic nerve and the external rectus.

It is difficult to recognise the different recti muscles by their insertions if we do not know whether the eye examined is a right or a left one. To determine this we should hold the globe with the optic nerve towards us, and in the natural position with the superior oblique tendon uppermost. The inferior oblique tendon will now point to the side to which the eye belongs, and we can consequently determine the different recti muscles.

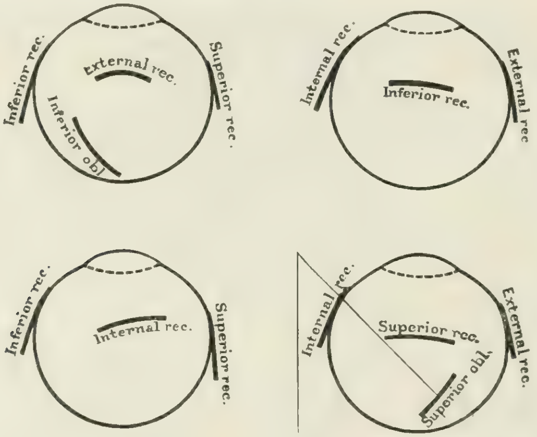
The internal rectus is inserted nearest (7 mm. from) the corneal border; the external rectus commonly, sometimes the superior, is inserted furthest from it (about 8 mm.). All the recti tendons are broad and thin, but that of the internal is the broadest (8 mm.); those of the external and inferior the narrowest (6 mm.)

The greatest interval between two neighbouring tendons is that between the superior and internal recti (about 12 mm.); the least is between the superior and external (7 mm.). The form of the lines of insertion of the different tendons varies considerably, the inferior being almost straight, the superior and external convex forwards, the internal further removed from the corneal border below than above.

The insertions of the obliques are at more than double the average distance of the insertions of the recti from the corneal border. That of the superior oblique is found on the superior surface of the sclerotic, about sixteen millimetres from the corneal edge, in the form of a line sloping from before backwards and inwards. The inferior oblique has a long fleshy insertion lying between the external rectus and the optic nerve entrance; the posterior end of the insertion, which is also the highest, is only about six millimetres from the optic nerve, and from this point it slopes forwards, outwards, and slightly downwards.

Several small nerves and two arteries may be seen running forwards and ultimately perforating the sclerotic not far from the entrance of the optic nerve. The two arteries are the long posterior ciliary; they both perforate the globe in the horizontal meridian, one on the outer, the other on the inner side. The short ciliary arteries are too small to be seen in an ordinary examination. The nerves are the long and short ciliary. Nearer the equator, the large venous trunks emerge; they can be traced for some distance in front of their exit as dark lines, running antero-posteriorly beneath the sclerotic. The optic nerve is seen in section, surrounded loosely by a thick outer sheath; in the centre of the nerve-section a small red spot indicates the position of the central retinal blood-vessels.

FIG. 474.—DIAGRAMMATIC VIEW OF THE INSERTIONS OF THE OCULAR MUSCLES. (After Merkel.)



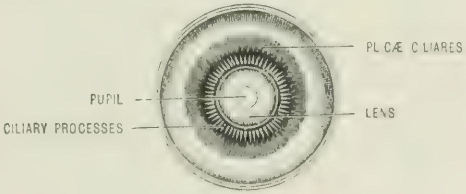
For ordinary dissections eyes of the sheep, pig, or bullock should be obtained. Divide an eyeball into fore and hind halves by cutting through it in the equatorial plane.

1. **Posterior hemisphere** seen from in front. This is much the same view that the ophthalmoscope affords us. Unless the eye be very fresh, however, the **retina** will have lost its transparency, and will now present the appearance of a thin whitish membrane, detached in folds from the underlying coats, but still adherent at the optic disc. The vitreous jelly lying within the retinal cup may be torn away. In the human eye the retina next the posterior pole is stained yellow (**macula lutea**). On turning the retina over, a little pigment may be seen adhering to its outer surface here and there. Cut through the retina close to the optic disc all round and remove it: note how easily it is torn. We now see a dark brown surface, consisting of the **retinal pigment layer,** adherent to the inner surface of the choroid. Brush off the retinal pigment under water. The **choroid** thus exposed can for the most part be fairly easily torn away from the thick sclerotic, as a lymph-space exists between them, but the attachment is firm around the optic nerve entrance, and also where the arteries and nerves join the choroid after penetrating the sclerotic. The choroid is darkly pigmented of a brown colour, with markings on its surfaces corresponding to the distribution of its large veins. The inner surface of the sclerotic

is of a light brownish colour, mainly from the presence of a delicate pigmented layer, the **membrana suprachoroidea,** which adheres partly to it, partly to the choroid, giving to their adjacent surfaces a flocculent appearance when examined under water.

2. **Anterior hemisphere** viewed from behind.—The round opening of the pupil is visible in the middle, with the large clear **crystalline lens** lying behind it. The retina proper extends forwards a little way from our line of section, and then ends abruptly in a wavy line called the **ora serrata,** beyond which it is only represented by a very thin membrane (**pars ciliaris retinæ**). Outside the periphery of the lens are a number of **ciliary processes** arranged closely together in a circle concentric with the pupil, and each radially elongated; posteriorly they are continuous with numerous fine folds, also radial, which soon get very indistinct as they pass backwards, but reach almost to the ora serrata (**plicæ ciliares**). Between the front of the ciliary processes and the edge of the pupil lies the **iris.** On removal of the retina the inner surface of all this region is seen to be darkly pigmented, but especially dark in front of the position of the ora serrata. Vitreous probably still adheres to the back of the lens, and by pulling upon it the lens can be removed along with its capsule and suspensory ligament; some pigment will now be found adhering to the front of the vitreous, torn from the ciliary processes, which are consequently now lighter in colour than before. The **lens-capsule** is transparent, and has a smooth glistening outer surface; through it a greyish star-shaped figure may be observed on the anterior and posterior surfaces of the lens. The **suspensory ligament** is a transparent membrane attached to the capsule of the lens about its equator, and is best seen by floating the lens in water in a glass vessel placed on a dark ground. On opening the capsule we expose the lens itself, which is superficially soft and glutinous to the touch, but becomes firmer as we rub off its outer layers and approach its centre. Carefully tear the choroid and iris from the sclerotic; a firm adhesion exists just behind the corneal periphery. Their outer surface thus exposed is found to be also rather darkly pigmented (as far forward as the base of the iris at least), but it shows a white ring corresponding to the adhesion just mentioned, and a pale area behind this ring indicates the position of the **ciliary muscle.** On this surface numerous white nerve-cords are visible running forwards.

FIG. 475.—EQUATORIAL SECTION OF EYEBALL: ANTERIOR SEGMENT VIEWED FROM BEHIND. (After Merkel.)



Observe that the iris, the ciliary processes, etc., and the choroid are all different parts of the same ocular tunic—mere local modifications of it. Similarly the sclerotic and cornea are seen to blend together to form one outer coat.

An eyeball should now be placed for half an hour in a freezing mixture of crushed ice and salt. It will thus become quite hard, and should at once be divided into two parts by cutting it antero-posteriorly through the centre of the cornea and the optic nerve. We thus gain another view of the relations of parts, the position of the lens between the aqueous and vitreous chambers, etc. On removing the lens, vitreous, and retina, and brushing off its pigment, the light markings corresponding to the choroidal veins (**venæ vorticosæ**) should be noted, and their distribution studied. Usually four vortices or fountain-like markings are found in the whole choroid, their points of junction situated at approximately equal distances from one another at about the line where the posterior and middle thirds of the globe meet. These sections should be kept for reference while following the further description of the ocular tunics.

1. The **outer, fibrous coat of the eye** is formed by the sclerotic and cornea, which pass into one another at the scleral sulcus. It consists throughout mainly of fine connective-tissue fibres, arranged in interlacing bundles, with small lymph-spaces at intervals between them. The naked-eye appearance of the two divisions of this fibrous coat is, however, quite different, the cornea being transparent, while the sclerotic is white and opaque.

The **sclerotic** encloses the posterior five-sixths or so of the eyeball, but there is a hole in it at the entrance of the optic nerve (**foramen scleræ**), only partially bridged across by fibres from its inner layers forming the **lamina cribrosa.** The fibre-bundles composing the sclerotic are arranged more irregularly than in the cornea, and run mainly in two directions, viz. from before backwards, and circularly; the circular fibres are particularly well developed just behind the sulcus. It is thickest (about 1 mm.) posteriorly, where it is strengthened chiefly by the outer sheath of the optic nerve, and partly also by the tissue surrounding the ciliary vessels and nerves. It becomes gradually thinner as it passes forwards, up to the line of insertion of the recti muscles, in front of which line it is again reinforced by their tendinous fibres becoming incorporated with it. In children the sclerotic is often so thin as to allow the underlying choroidal pigment to show through, appearing then of a bluish white. In the aged, again, it is sometimes yellowish. It always contains a few pigment cells, but these are in the deep layers, and only become visible externally where the sclerotic is pierced by vessels and nerves going to the choroid. It is itself almost non-vascular, but quite at its anterior end a large venous sinus (canal of Schlemm) runs in its deeper layers circularly around the cornea. Just in front of this sinus, at the corneal **limbus,** the sclerotic merges into the cornea, its deep layers changing first, and finally the superficial ones.

The **cornea** is thickest at its periphery, and becomes gradually thinner towards its centre; the curvature of its posterior is consequently greater than that of its anterior surface, but even the latter is more curved than the surface of the sclerotic. In the cornea proper, fibre-bundles are arranged so as to form a series of superposed lamellæ, each of which is connected here and there to the adjacent ones by fibres passing from one to the other, so that they can only be torn apart with difficulty. The corneal lymph-spaces communicate with one another by very fine canals, and thus not only is a thorough lymph-circulation provided for, but the protoplasm with which these spaces are partially occupied may be also regarded as continuous throughout. It contains no blood-vessels, with the exception of a rich plexus at its extreme periphery, on which its nutrition is ultimately dependent.

The most superficial part of the true cornea appears homogeneous, even when highly magnified (**Bowman's membrane**), though there is reason to believe that its structure only differs from that already described in the closeness of its fibrous texture; the two parts are certainly connected by fine fibres. Anteriorly, the cornea is covered by an extension of the ocular conjunctiva, in the form of an epithelium several layers deep. Posteriorly, the cornea is lined by a firm, thin, glass-like layer (**membrane of Descemet, posterior elastic lamina**), distinct from the corneal tissue both anatomically and chemically. At the periphery this membrane breaks up into a number of fibres, which mainly arch over to join the base of the iris (**ligamentum pectinatum iridis**). The interstices between these fibres constitute spaces (**spaces of Fontana**) freely communicating with the aqueous chamber on the one hand, and indirectly with the canal of Schlemm on the other. Descemet's membrane is in turn lined by a single layer of flat cells, which are continuous peripherally with cells lining the spaces of Fontana and the anterior surface of the iris. The cornea is richly supplied with nerves, particularly in its most superficial layers.

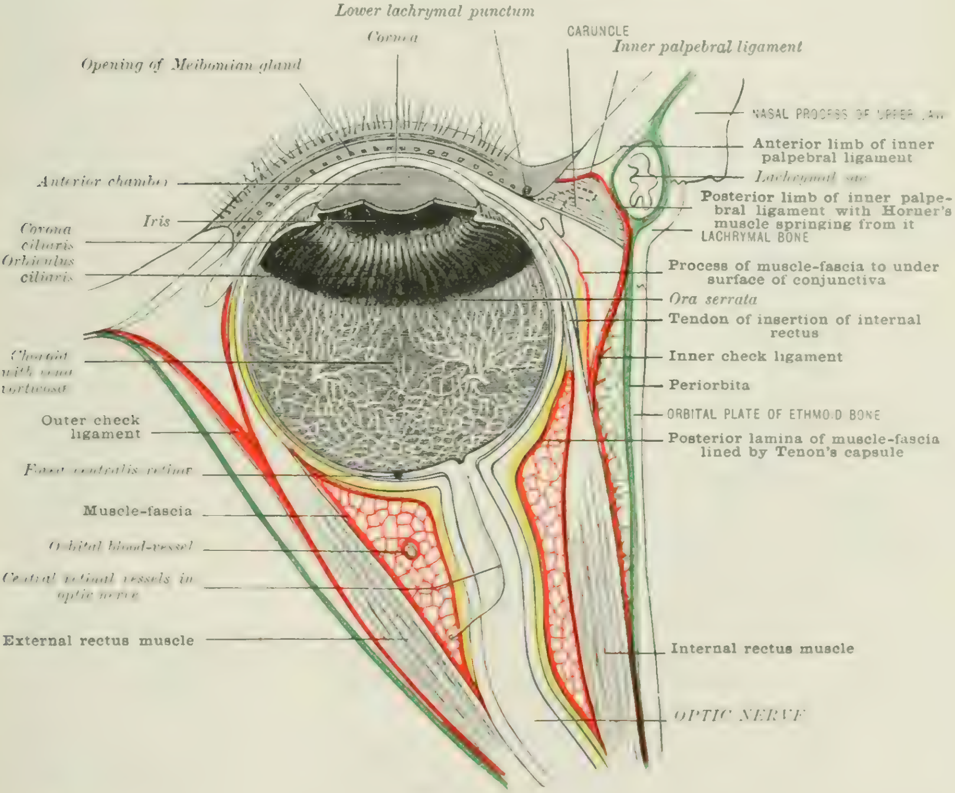
2. The dark, **middle,** or **vascular coat of the eye,** generally known as the **uveal tract,** is formed by the iris, ciliary body, and choroid. It is closely applied to the sclerotic, but actually joins it only at the anterior and posterior limits of their course together, viz. at the scleral sulcus, and around the optic nerve entrance. In front of the sulcus the middle coat no longer lines the outer, being separated from it (i.e. the iris from the cornea) by a considerable space filled with fluid, called the anterior aqueous chamber. The uveal tract has two openings in it; a larger one in front, the pupil, and a smaller one behind, for the passage of the optic nerve. Its structure is that of a pigmented connective tissue, supporting numerous blood-vessels and containing many nerves and two deposits of smooth muscle-fibres.

The **choroid** forms the posterior part of the uveal tract, and extends, with slowly diminishing thickness, forwards as far as the ora serrata. Its outer and inner surfaces are both formed by non-vascular layers; that covering the outer, the **membrana suprachoroidea,** is pigmented, arranged in several fine loose lamellæ, and has been seen in our dissection; that covering the inner surface is a thin, transparent, homogeneous membrane, called the vitreous lamina of the choroid, or the **membrane of Bruch.** The intervening choroidal stroma is very rich in blood-vessels, which are of largest size next its outer surface, and become progressively smaller as we approach the vitreous lamina, next to which we find a layer of closely placed wide capillaries, called the **chorio-capillaris.** The pigment becomes less in amount as we pass inwards, and finally ceases, being absent entirely from the chorio-capillaris and vitreous lamina.

In front of the ora serrata the uveal coat becomes considerably modified, and the part reaching from here to the iris may conveniently be termed the ciliary region of the tract, or **ciliary body.** Its superficial aspects have been already briefly described. In front, the ciliary processes, about seventy in number, project towards the interior of the eye, forming the **corona ciliaris.** Behind this part lies the **orbiculus ciliaris,** whose inner surface is almost smooth, faint radial folds only being present, three or four of which join each ciliary process. The more minute structure of this ciliary region resembles closely that of the choroid, except that the chorio-capillaris is no longer present, that the stroma is thicker and richer in blood-vessels, and that a muscular element (ciliary muscle) exists between the vascular layer and the membrana suprachoroidea. On antero-posterior section the ciliary body is triangular; the shortest side looks forward, and from about its middle the iris arises; the two long sides look respectively inwards and outwards, the inner having the ciliary processes upon it, while the outer is formed by the **ciliary muscle.** This muscle possesses smooth fibres and consists of an outer and an inner division; in the outer the fibres run longitudinally, inserted into the outer fibrous coat of the eye at the sclero-corneal junction in front, and passing backwards to join the outer layers of the orbiculus and choroid; the inner contains circularly running fibres situated next to the ciliary processes. The entire muscle is destitute of pigment, and therefore is recognisable in the section by its light colour. The whole

FIG. 476.—DIAGRAMMATIC HORIZONTAL SECTION OF EYEBALL AND ORBIT.
(After Fuchs, much modified.)

Periorbita *green*; muscle-fascia *red*; Tenon's capsule *yellow*.


Lower lachrymal punctum
Cornea
CARUNCLE
Inner palpebral ligament
Opening of Meibomian gland
NASAL PROCESS OF UPPER JAW
Anterior limb of inner palpebral ligament
Lachrymal sac
Anterior chamber
Posterior limb of inner palpebral ligament with Horner's muscle springing from it
LACHRYMAL BONE
Iris
Corona ciliaris
Orbiculus ciliaris
Process of muscle-fascia to under surface of conjunctiva
Ora serrata
Tendon of insertion of internal rectus
Choroid with venæ vorticosæ
Inner check ligament
Periorbita
ORBITAL PLATE OF ETHMOID BONE
Outer check ligament
Posterior lamina of muscle-fascia lined by Tenon's capsule
Fovea centralis retinæ
Muscle-fascia
Orbital blood-vessel
Central retinal vessels in optic nerve
External rectus muscle
Internal rectus muscle
OPTIC NERVE

thickening of the uveal tract in this region, muscle and folds and processes together, is named the ciliary body.

The **iris** projects into the interior of the front half of the eye in the form of a circular disc perforated in the middle. The appearance of its anterior surface has already been described. Its posterior surface exhibits numerous radial folds running from the ciliary processes to near the pupillary border; a thick layer of black pigment covers it and curls round its inner edge, so as to come into view all round the pupil as seen from in front. The peripheral or ciliary border of the iris is continuous with the front of the ciliary body, where it also receives fibres from the ligamentum pectinatum iridis; in other respects the iris is quite free, merely resting on the front of the lens-capsule near the pupil. Its stroma is spongy in character, being made up of vessels covered by a thick adventitia, running from the periphery to the pupillary border, with interspaces filled by branching pigment cells, which are particularly abundant near the front surface. Deep in the stroma, running round near the pupillary border, we find a broad flat band of smooth muscle fibres, constituting the **sphincter iridis.** Immediately behind the vascular tissue lies a thin membrane, consisting of fine, straight fibres running radially from the ciliary border to just behind the sphincter. The nature of these fibres has long been in dispute, but they are now accepted as being undoubtedly smooth muscular, a **dilator iridis.**

The sphincter iridis and the ciliary muscle are supplied by the third nerve, and the dilator iridis by the sympathetic, all by way of the ciliary ganglion.

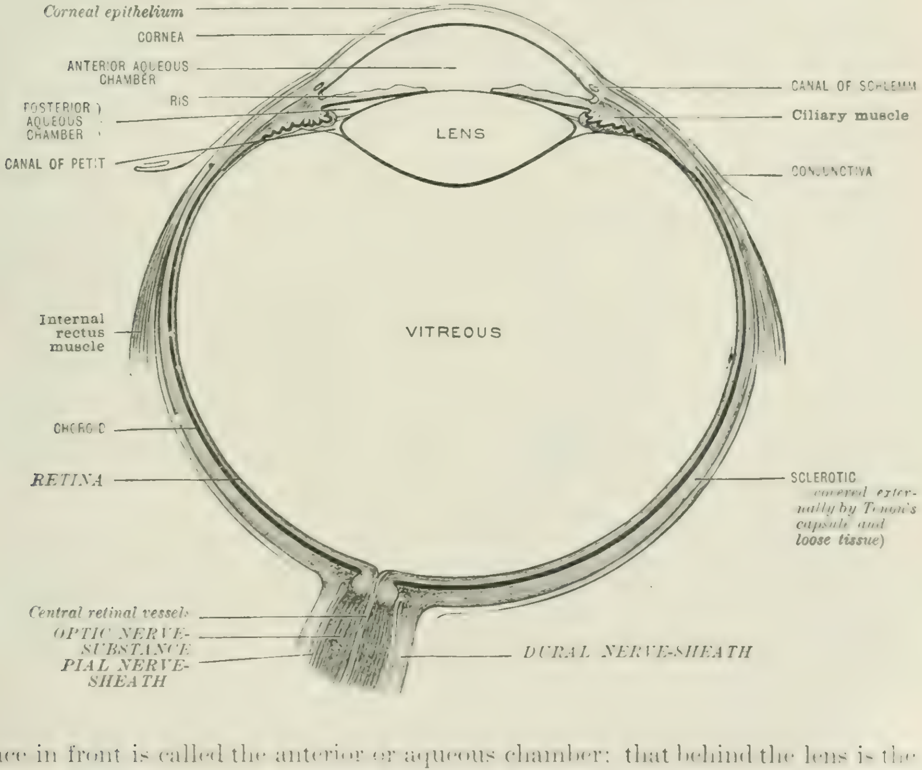
Quite posteriorly is the pigment already mentioned, really consisting of two layers of pigmented cells, each layer representing the extension forwards of one subdivision of the retina. The front of the iris is covered by a delicate epithelial layer, a continuation of that lining Descemet's membrane. The colour of the iris in different individuals depends upon the amount of *stromal* pigment.

3. **The innermost or nervous coat.**—The inner surface of the uveal tract is everywhere lined by a layer of pigment of corresponding extent, which usually adheres to it closely on dissection. Developmentally, however, this general pigment lining is quite distinct from the uveal coat, and represents the *outer wall* of the secondary optic vesicle or embryonic retina: it consists of a single layer of pigmented epithelial cells. The amount of pigment is greatest anteriorly, over the ciliary region and iris, and there is again a small local increase posteriorly, corresponding to the macula lutea and to the edge of the optic foramen. In the ciliary region these cells have recently been described as lining numerous narrow tubular depressions in the inner part of the uveal tract, and they seem here to have a special function, viz. that of secreting the intraocular fluids.

From the manner in which the secondary optic vesicle, or *optic cup*, is formed, its two walls are necessarily continuous in front, at what may be termed the *lip* of the cup: we have just observed that the outer wall lines the uveal coat everywhere and corresponds in extent; consequently, the lip must be looked for at the edge of the pupil, i.e. at the termination of this coat anteriorly. The *inner wall* of the cup, consequently, reaches from the lip, or pupillary edge, in front, to the optic stalk or nerve behind, and is in close apposition to the pigment-epithelium; unlike the outer, however, this wall is represented in the developed eye by tissues very dissimilar in structure in different parts of its extent. Tracing it backwards from the pupillary edge, we find that over the whole posterior surface of the iris it exists as a single layer of pigmented epithelium, the developmental changes having here produced a result similar to what we have found throughout in the outer wall: here, accordingly, we have a double layer of pigment cells. At the root of the iris the single inner layer of cells still exists; but now they become destitute of pigment, and this condition obtains over the entire ciliary region, constituting what is known as the **pars ciliaris retinæ.** At the line of the ora serrata the tissue derived from the inner wall abruptly increases in thickness, and rapidly acquires that complexity of structure characteristic of the **retina proper,** which extends from here to the optic nerve. It consists of several layers—nerve-fibres, nerve-cells, and nerve-epithelium—held together by a supporting framework of delicate connective tissue. The nerve-epithelium is on the outer surface, immediately applied to the pigment-epithelium; at the posterior pole of the eye a small spot (**fovea centralis**) exists, where this is the only retinal layer represented, and where consequently the retina is extremely thin. The nerve-fibres run on the inner surface of the retina and are continuous with those of the optic nerve; they constitute the only retinal layer that is continued into the intraocular end of the nerve. The nerve-cells are found between these surface layers. The larger blood-vessels of the retina run in the inner layers, and none encroach on the layer of nerve-epithelium.

Within the coats mentioned, the interior of the eyeball is fully occupied by contents, which are divided into three parts, and differently named according to their consistence and anatomical form. They are all transparent, as through them the light has to pass so as to gain the retina. Of these the only one that is sharply and independently outlined is the lens, which is situated in the anterior half of the globe at the level of the ciliary processes, where it is suspended between the other contents, which fill respectively the space in front of it and the space behind it. The space in front is called the anterior or aqueous chamber; that behind the lens is the vitreous chamber.

FIG. 477.—SEMI-DIAGRAMMATIC HORIZONTAL SECTION THROUGH EYEBALL AND OPTIC NERVE. (After Eltinger. Reduced and altered.)


Corneal epithelium
CORNEA
ANTERIOR AQUEOUS CHAMBER
IRIS
POSTERIOR AQUEOUS CHAMBER
CANAL OF PETIT
LENS
CANAL OF SCHLEMM
Ciliary muscle
CONJUNCTIVA
Internal rectus muscle
VITREOUS
CHOROID
RETINA
SCLEROTIC
covered externally by Tenon's capsule and loose tissue)
Central retinal vessels
OPTIC NERVE-SUBSTANCE
PIAL NERVE-SHEATH
DURAL NERVE-SHEATH

The **lens** is a biconvex body, with its surfaces directed anteriorly and posteriorly; these surfaces meet at its rounded-off edge or **equator**, which is near (but does not touch) the ciliary processes all round. The posterior is considerably more convex than the anterior surface; the central part of each surface is called its **pole**. The lens is closely encased in a hyaline elastic capsule, thicker over the anterior than over the posterior surface. Thus enclosed, it is held in position in the globe by a suspensory ligament, attached to its capsule near the equator all round, and swung from the ciliary region. Posteriorly, the lens rests in a cup formed by the front part of the vitreous, while its anterior capsule is in contact with the aqueous fluid and lies close against the back of the pupillary border of the iris. When in position the lens measures nine millimetres across, and about four millimetres between its poles. On each surface a series of fine, sinuous, grey lines can be seen radiating from the pole towards the equator, called respectively the anterior and posterior

stellate figures. The lines observable on the posterior are always so placed as to be intermediate with those on the anterior surface, so that on viewing them *through the lens* they occupy a position corresponding to the intervals between the lines on the anterior surface. The lens-capsule is comparatively brittle, and can be readily cut through when scraped with a sharp-pointed instrument; on doing so the divided edges curl outwards, away from the lenticular substance. When removed from its capsule, the outer portion of the lens is found to be soft and glutinous, but its substance gets progressively firmer as we approach the centre. This harder central part is known as the **nucleus,** and the surrounding softer matter as **cortex.** The cortical part shows a tendency to peel off in successive layers. It consists of long fibres, the ends of which meet in front and behind at the anterior and posterior stellate figures.

Histologically the capsule is not in immediate contact with the cortex over the front surface of the lens, a single layer of cells intervening, called the **subcapsular epithelium.**

The **suspensory ligament of the lens** is formed by a thickening of the anterior part of a membrane enclosing the vitreous, strengthened by numerous fibres derived from the folds of the ciliary region. Its chief attachments to the lens-capsule are a little in front of and behind the equator, and the space included between the most anterior and most posterior divisions of the ligament is termed the **canal of Petit.** This space is bridged across by fine intermediate suspensory fibres, and is occupied by fluid.

The **vitreous humour** is a transparent, colourless, jelly-like mass, enclosed in a delicate, clear, structureless membrane, called the *hyaloid membrane.* This latter is closely applied to the back of the posterior lens-capsule and of the suspensory ligament, and to the inner surface of the pars ciliaris retinæ, retina proper, and optic papilla. Although possessing some degree of firmness, the vitreous humour contains quite 98 per cent. of water, and has no definite structure. Membranes have been described in it, but these are really artificial products. In certain situations spaces exist in the vitreous mass, the most determinate of which runs in the form of a canal from the optic papilla to the posterior pole of the lens, corresponding to the position of the fœtal hyaloid artery (**hyaloid canal, or canal of Cloquet**). Other very fine spaces are described running circularly in the peripheral part of the vitreous concentric with its outer surface. Microscopically, wandering cells are found in the vitreous, which often here assume peculiar forms which the observer can, not infrequently, study subjectively.

The **aqueous humour** is a clear, watery fluid, occupying the space between the cornea on the one hand, and the ciliary body, suspensory ligament, and lens on the other. The iris, projecting into this space, has both its surfaces bathed in the aqueous; but, as its inner part rests on the lens, it is regarded as dividing the space into two parts, an **anterior** larger, and a **posterior** smaller **aqueous chamber,** which communicate freely through the pupil.

Ciliary nerves of the eyeball.—The long and short ciliary nerves, after perforating the sclerotic, run forward between it and the choroid to the ciliary region, where they form a plexus, from which proceed branches for the ciliary muscle, the iris, and the cornea. The nerves of the iris enter it at its ciliary border, and run towards its pupillary edge, losing their medullary sheath sooner or later, and supplying specially the sphincter muscle. The corneal nerves form an annular plexus near the limbus, from which a few twigs proceed to the sclerotic and conjunctiva, while most of the offsets enter and run radially in the corneal stroma, branching and anastomosing so as to form a plexus. The nerves entering the cornea are about sixty in number, each containing from two to twelve non-medullated nerve-fibres (page 753).

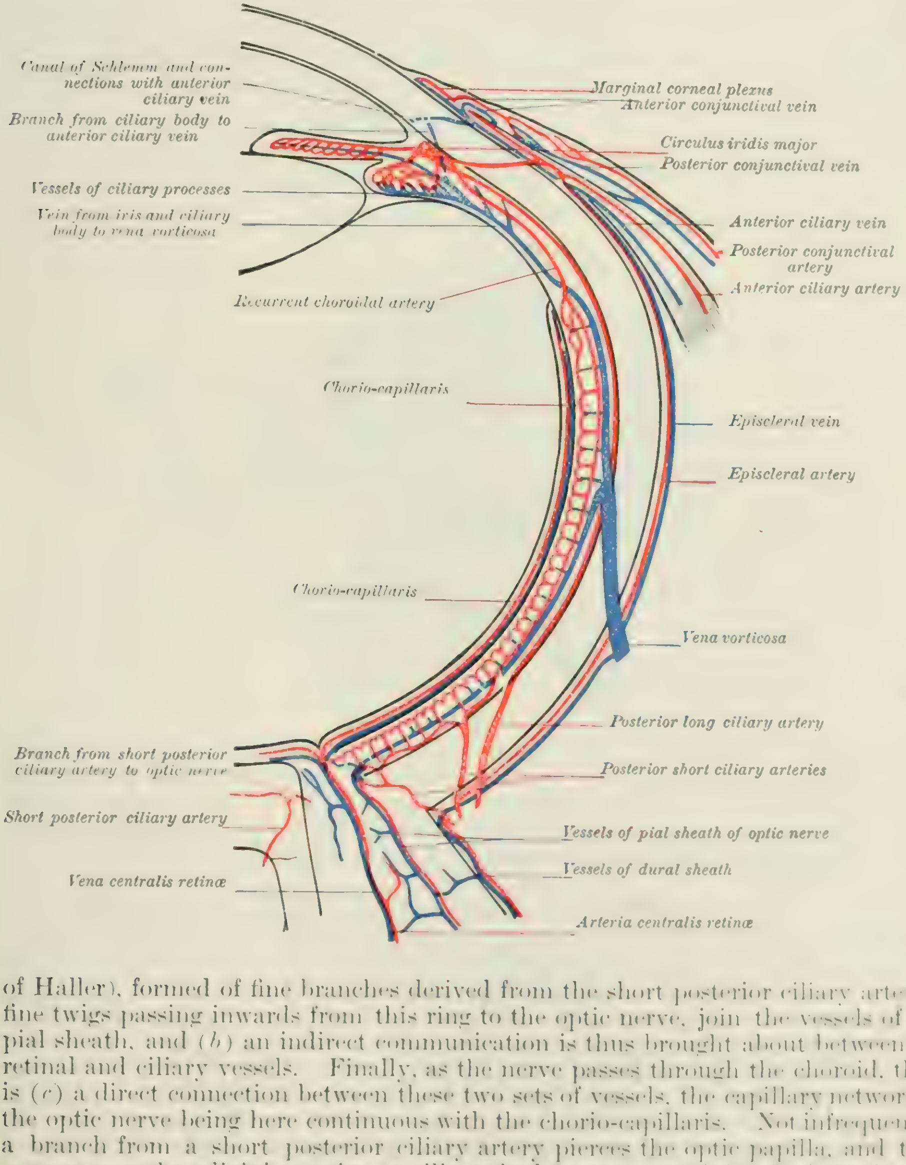
Blood-vessels of the eyeball.—The ocular tissues receive blood from two sets of vessels, viz. the **retinal** and the **ciliary arteries.**

1. The **arteria centralis retinæ** either comes direct from the ophthalmic artery, or from one of its branches near the apex of the orbit. Entering the optic nerve twenty millimetres or less behind the globe, it runs forward in its axis to the end of

the nerve-trunk, and then divides into branches which run in the inner layers of the retina, and divide dichotomously as they radiate towards the equator. The smaller branches lie more deeply in the retina, but none penetrate into the nerve-epithelium, so that the fovea centralis is non-vascular. In the retina, the branches of the central artery do not communicate with any other arteries, but while still in the optic nerve fine communications take place between this artery and neighbouring vessels. Thus (*a*) minute twigs from it, which help to nourish the axial part of the nerve, communicate with those running in the septa derived from the pial sheath. Again, as the nerve passes through the sclerotic, it is surrounded by a vascular ring (circle of Haller), formed of fine branches derived from the short posterior ciliary arteries; fine twigs passing inwards from this ring to the optic nerve, join the vessels of the pial sheath, and (*b*) an indirect communication is thus brought about between the retinal and ciliary vessels. Finally, as the nerve passes through the choroid, there is (*c*) a direct connection between these two sets of vessels, the capillary network of the optic nerve being here continuous with the chorio-capillaris. Not infrequently, a branch from a short posterior ciliary artery pierces the optic papilla, and then courses over the adjoining retina (a cilio-retinal artery), supplying the latter in part in place of the central artery.

FIG. 478.—DIAGRAMMATIC REPRESENTATION OF THE BLOOD-VESSELS OF THE EYEBALL. (Leber.)

Arteries *red*; veins *blue*.


Canal of Schlemm and connections with anterior ciliary vein
Branch from ciliary body to anterior ciliary vein
Vessels of ciliary processes
Vein from iris and ciliary body to vena vorticosa
Recurrent choroidal artery
Chorio-capillaris
Chorio-capillaris
Branch from short posterior ciliary artery to optic nerve
Short posterior ciliary artery
Vena centralis retinæ
Marginal corneal plexus
Anterior conjunctival vein
Circulus iridis major
Posterior conjunctival vein
Anterior ciliary vein
Posterior conjunctival artery
Anterior ciliary artery
Episcleral vein
Episcleral artery
Vena vorticosa
Posterior long ciliary artery
Posterior short ciliary arteries
Vessels of pial sheath of optic nerve
Vessels of dural sheath
Arteria centralis retinæ

The **vena centralis retinæ** returns the blood of the corresponding artery.

2. **The ciliary system of blood-vessels** (pages 500, 501, and 625).—There are three sets of arteries belonging to this system, all derived directly or indirectly from the ophthalmic artery.

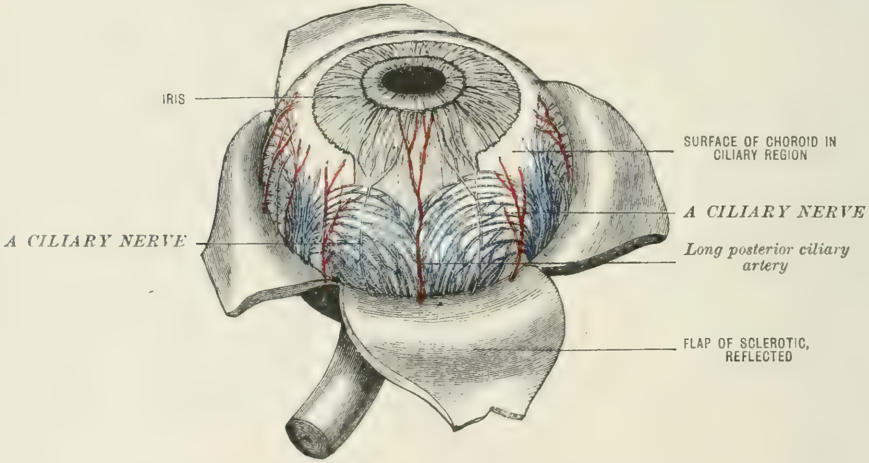
(1) **Short posterior ciliary arteries,** twelve to twenty in number, pierce the sclerotic round the optic nerve entrance, and are distributed in the choroid. Before entering the eyeball, small twigs are given off to the adjoining sclerotic and to the dural sheath of the optic nerve.

(2) Two **long posterior ciliary arteries,** piercing the sclerotic further from the nerve than the short ciliaries, run horizontally forwards between the sclerotic and choroid, one on each side of the globe. On arriving at the ciliary body, they join with the anterior ciliary arteries, forming the **circulus iridis major,** which sends off branches to the ciliary processes and the iris. The long ciliaries also give twigs to the ciliary muscle, and small recurrent branches run backwards to anastomose with the short ciliary arteries. The arteries of the iris run radially to the pupillary border, anastomosing with one another opposite the outer border of the sphincter so as to form the **circulus iridis minor.**

(3) The **anterior ciliary arteries** come from the arteries of the four recti muscles, one or two from each; they run forwards, branching as they go, and finally pierce the sclerotic near the corneal border. Outside the globe they send twigs to the adjoining sclerotic, to the conjunctiva, and to the border of the cornea. After passing through the sclerotic the arteries enter the ciliary muscle, where they end in twigs to the muscle and to the circulus iridis major, and recurrent branches to the choroid.

FIG. 479.—SURFACE OF CHOROID AND IRIS EXPOSED BY REMOVAL OF SCLEROTIC AND CORNEA, SHOWING DISTRIBUTION OF BLOOD-VESSELS AND NERVES.

(Twice natural size. After Zinn.)


IRIS
SURFACE OF CHOROID IN CILIARY REGION
A CILIARY NERVE
A CILIARY NERVE
Long posterior ciliary artery
FLAP OF SCLEROTIC, REFLECTED

Veins.—The venous blood from almost the whole uveal tract (choroid, ciliary processes and iris, and part of the ciliary muscle) ultimately leaves the eyeball by (1) the **venæ vorticosæ,** which have been already noticed in describing an antero-posterior section through the globe. One large vein passes backwards from each vortex, piercing the sclerotic obliquely; it is joined by small episcleral veins when outside the globe.

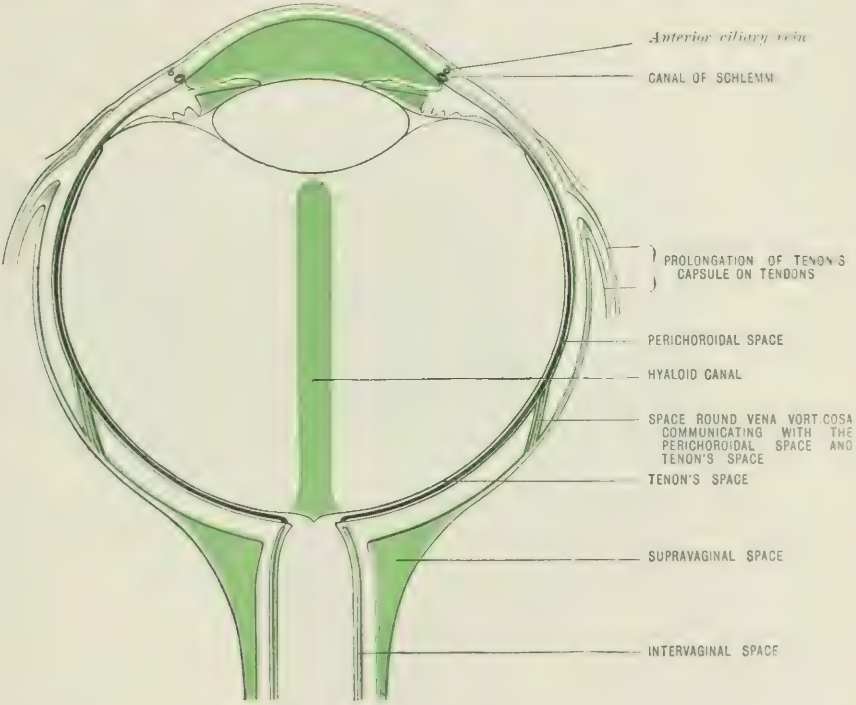
(2) The **anterior ciliary veins** commence by the junction of a few small veins of the ciliary muscle; they pass outwards through the sclerotic near the corneal border, receiving blood from the veins in connection with Schlemm's canal, and afterwards from episcleral and conjunctival veins, and from the marginal corneal plexus. Finally they join the veins running in the recti muscles.

Lymphatic system of the eyeball.—Apart from those in the conjunctiva there are no lymphatic *vessels* in the eyeball, but the fluid is contained in *spaces* of various sizes. These are usually divided into an anterior and a posterior set.

1. **Anteriorly,** we have the anterior and posterior aqueous chambers, which communicate freely through the pupil. The aqueous humour is secreted in the posterior of these chambers, from the vessels of the ciliary body and posterior surface of the iris (see also page 849). The stream passes mainly forwards through the pupil into the anterior aqueous chamber, whence it escapes slowly by passing through the spaces of Fontana into Schlemm's canal, and thence into the anterior ciliary veins. Part of the lymph-stream passes from the posterior aqueous chamber backwards into the canal of Petit, out of which fluid can pass into the lens substance, or diffuse itself into the front of the vitreous.

In the **cornea** the lymph travels in the spaces already mentioned as existing between the fibre-bundles, and in the nerve-channels, and at the periphery of the cornea it flows off into the lymphatic vessels of the conjunctiva.

Fig. 480.—The Lymphatics of the Eyeball. (Diagrammatic. After Fuchs.)


Anterior ciliary vein
CANAL OF SCHLEMM
PROLONGATION OF TENON'S CAPSULE ON TENDONS
PERICHOROIDAL SPACE
HYALOID CANAL
SPACE ROUND VENA VORTICOSA COMMUNICATING WITH THE PERICHOROIDAL SPACE AND TENON'S SPACE
TENON'S SPACE
SUPRAVAGINAL SPACE
INTERVAGINAL SPACE

In the **iris** there is a system of lymphatic spaces opening anteriorly on its free surface by the crypts previously described, and communicating peripherally with the spaces of Fontana.

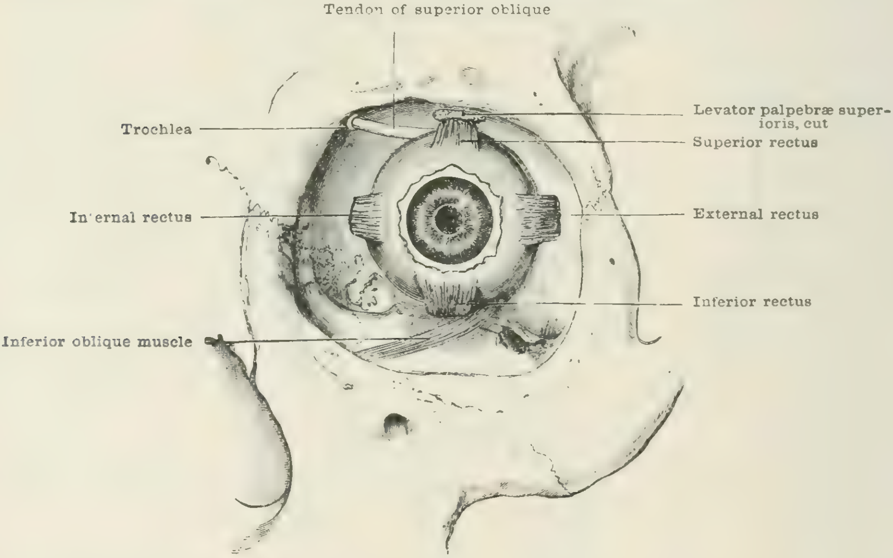
2. **Posteriorly,** we have (*a*) the central or hyaloid canal, between the posterior pole of the lens and the optic nerve entrance, and (*b*) the perivascular canals of the retina; the lymph from both of these situations flows into the spaces of the optic nerve, which communicate with the intervaginal space of the nerve, and thus with the great intracranial spaces. Further, between choroid and sclerotic, we have (*c*) the perichoroidal space, which gets the lymph from the choroid, and communicates with Tenon's space outside the sclerotic by the perforations corresponding to the vasa vorticosa and posterior ciliary arteries, and with the intervaginal space around the optic nerve entrance. Tenon's space, again, is continuous with the supravaginal space around the optic nerve, which communicates both with the intervaginal spaces, with the lymph spaces of the orbit, and directly with the intracranial spaces at the apex of the orbit.

CAVITY OF THE ORBIT

General Arrangement of its Contents

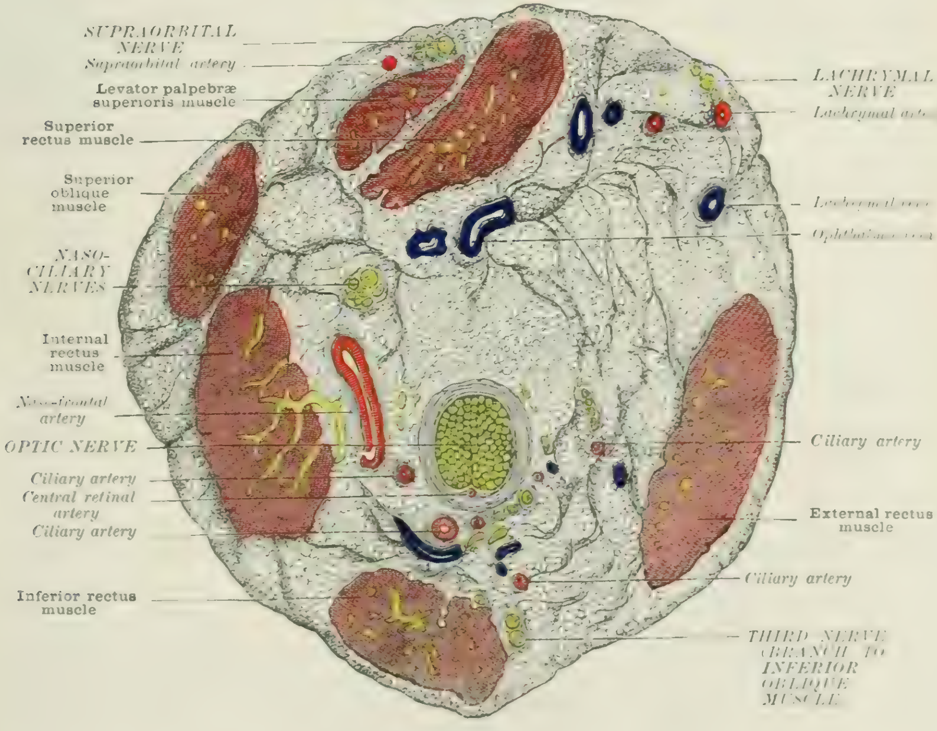
The anterior wider half of the cavity is mainly occupied by the eyeball, which lies almost axially, but is rather nearer to the upper and outer than it is to the other walls. The posterior two-thirds of the globe are in relation with soft parts, chiefly muscles and fat, and its posterior pole is situated midway between the base (or opening) and the apex of the orbital cavity. The anterior third of the eyeball is naturally free, except for a thin covering of the conjunctiva, and projects slightly beyond the opening of the orbit, the degree of prominence varying with the amount of orbital fat, and also to some extent with the length of the globe. A straight line joining the inner and outer orbital margins usually cuts the eye behind the cornea—externally behind the ora serrata, nasally further forward, at the junction of the ciliary body and iris. The globe is held in position by numerous bands of connective tissue. The lachrymal gland lies under the outer part of the roof of the orbit anteriorly. The orbital fat occupies the spaces between the orbital muscles, and is in greatest amount immediately behind the eyeball; it also exists between the muscles and the orbital walls in the anterior half of the cavity. Six muscles, viz. the four recti, the superior oblique, and the levator palpebræ superioris, arise at the apex of the orbit, and diverge as they pass forwards. The recti muscles—superior, inferior, external, and internal—run each near the corresponding orbital wall, but the superior is overlapped in part by the levator palpebræ. The superior oblique lies about midway between the superior and internal recti. A seventh muscle, the inferior oblique, has a short course entirely in the anterior part of the orbit, coming from its inner wall and passing beneath the globe between the termination of the inferior rectus and the orbital floor. The optic nerve with its sheaths passes from the optic foramen to the back of the eyeball, surrounded by the orbital fat, and more immediately by a loose connective tissue. Among the contents of the cavity are also to be enumerated many vessels and nerves, and fibrous tissue septa, while its walls are clothed by periosteum (periorbita).

Fig. 481.—Left Eyeball seen in its Normal Position in the Orbit, with View of the Ocular Muscles. (After Merkel, modified.)



The **muscles of the orbit** are seven in number, of which six are *ocular*, i.e. are inserted into the eyeball and rotate it in different directions. These ocular muscles are arranged in opponent pairs, viz. **superior** and **inferior recti, superior** and **inferior obliques, external** and **internal recti.** With the exception of the short inferior oblique, they all arise from the back of the orbit along with the seventh orbital muscle, the **elevator of the upper lid.** All these long muscles take their origin from the periosteum in the vicinity of the optic foramen. The four recti muscles arise from a fibrous ring, which arches close over the upper and inner edge of the foramen, and extends down and out so as to embrace part of the opening of the sphenoidal fissure. Their origins may be said at first to form a short, common, tendinous tube, from which the individual muscles soon separate, taking the positions indicated by their respective names. The external rectus has two origins from bone, one on either side of the sphenoidal fissure. But in the fresh state the fissure is here bridged across by fibrous tissue, from which this rectus also springs, so that its origin is in reality continuous. The part of this fibrous ring nearest the foramen (corresponding to the origins of the superior and internal recti) is closely connected with the outer sheath of the optic nerve. The remaining two long muscles arise just outside the upper and inner part of the abovementioned ring, and are often partially united; the levator palpebræ tendon is in close relation to the origin of the superior rectus, while the superior oblique arises from the periosteum of the body of the sphenoid bone one or two millimetres in front of the origin of the internal rectus.

FIG 482.—SECTION THROUGH CONTENTS OF RIGHT ORBIT 8-11 MM. BEHIND THE EYEBALL, VIEWED FROM BEHIND. (After Lange.)


SUPRAORBITAL NERVE
Supraorbital artery
Levator palpebræ superioris muscle
Superior rectus muscle
Superior oblique muscle
NASO-CILIARY NERVES
Internal rectus muscle
Naso-frontal artery
OPTIC NERVE
Ciliary artery
Central retinal artery
Ciliary artery
Inferior rectus muscle
LACHRYMAL NERVE
Lachrymal artery
Lachrymal vein
Ophthalmic vein
Ciliary artery
External rectus muscle
Ciliary artery
THIRD NERVE (BRANCH TO INFERIOR OBLIQUE MUSCLE

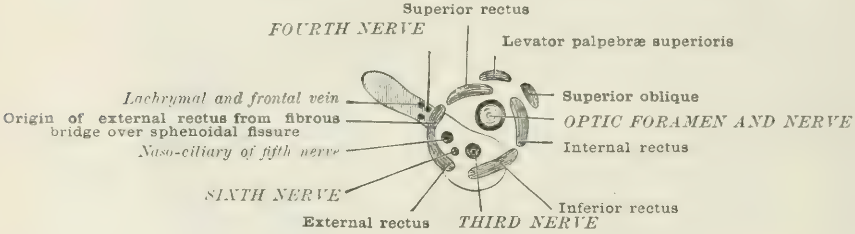
The **four recti muscles** lie rather close to the corresponding orbital walls for the first half of their course, the superior rectus, however, being overlapped in part by the levator palpebræ; they then turn towards the eyeball, running obliquely through the orbital fat, and are finally inserted by broad, thin tendons into the sclerotic in front of the equator. The thickest of these muscles is the internal rectus, next the external, then the inferior, and the superior rectus is the thinnest.

As regards length, the muscular belly of the superior rectus has the longest course, and the others diminish in the order—internal, external, and inferior rectus. The external rectus is supplied by the sixth nerve. The other three recti muscles are all supplied by the third nerve.

The **levator palpebræ superioris** courses along the roof of the orbit close to the periosteum for the greater part of its course, partially overlapping the superior rectus; it finally descends through the orbital fat, and widens out to be inserted into the root of the upper lid. It may be briefly described as being inserted in two distinct layers separated by a horizontal interval. The upper or anterior layer of insertion is fibrous, and passes in front of the tarsus, where it comes into relation with fibres of the orbicularis. The lower layer consists of smooth muscle (Müller's **superior palpebral muscle**) and is inserted along the upper border of the tarsus. The levator has also connections with the sheath of the superior rectus. These different insertions of the muscle will be referred to later along with the description of the orbital fasciæ and of the upper eyelid. It gets its nervous supply from the third nerve, but the smooth muscle developed in its lower layer of insertion is supplied by the sympathetic nervous system. As its name expresses, its *action* is to raise the upper lid and to support it while the eye is open.

The **superior oblique** runs forward close to the inner part of the orbital roof until it reaches the fossa trochlearis near the internal angular process, where it becomes tendinous and passes through a fibro-cartilaginous pulley attached to the fossa just named. On passing through this pulley, or **trochlea,** the tendon bends at an angle of 50°, running backwards and outwards under the superior rectus to its insertion into the sclerotic. It is supplied by the fourth nerve.

Fig. 483.—Diagrammatic Representation of Origins of Ocular Muscles at the Apex of the Right Orbit.
(After Schwalbe, slightly altered.)

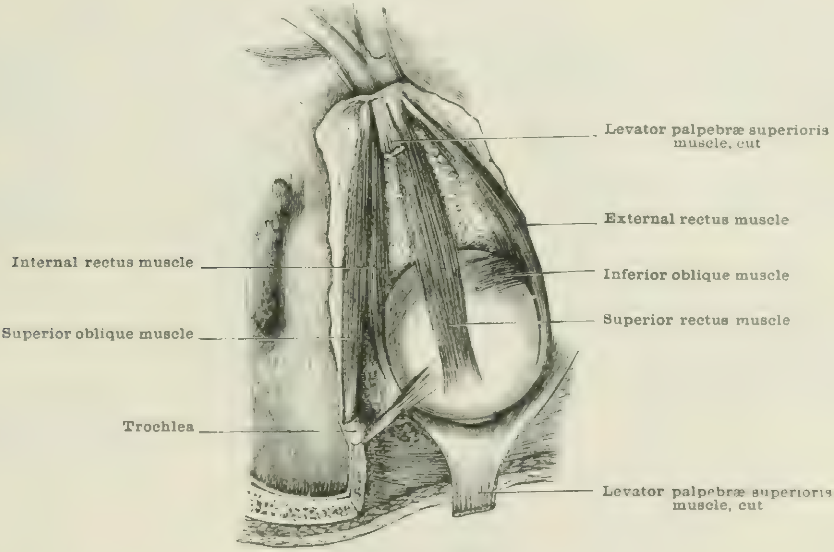

Superior rectus
FOURTH NERVE
Levator palpebræ superioris
Lachrymal and frontal vein
Superior oblique
Origin of external rectus from fibrous bridge over sphenoidal fissure
OPTIC FORAMEN AND NERVE
Naso-ciliary of fifth nerve
Internal rectus
SIXTH NERVE
Inferior rectus
External rectus
THIRD NERVE

The **inferior oblique** arises from the front of the orbit, about the junction of its inner and lower walls, just external to the lower end of the lachrymal groove. It runs, in a sloping direction, outwards and backwards, lying at first between the inferior rectus and the orbital floor, then between the external rectus and the globe; finally it ascends slightly, to be inserted by a short tendon into the sclerotic at the back of the eye. Its nervous supply is derived from the third nerve. The precise manner of insertion of the different ocular muscles has been described above in our Examination of the Eyeball. (For Muscles of the Eyelids and Eyebrows, see pages 429 and following.)

Action of the ocular muscles.—While rotating the globe so that the cornea is turned in different directions, the ocular muscles do not alter the position of the eyeball in the orbit either laterally, vertically, or antero-posteriorly. In speaking, therefore, of the eye being moved *upwards*, or *outwards*, etc., it is the altered position of the cornea or front of the eye that we mean to express; it is manifest that, if the cornea moves up, the back of the eyeball must simultaneously be depressed, and similarly with other movements. All the movements of the globe take place by rotation, on axes passing through the centre. Though the possible axes are numerous in combined muscular action, there are three **principal axes** of rotation of the eyeball, and in reference to these the action of individual muscles must be described. Two of these axes are horizontal, and one vertical; they all pass through the centre of rotation at right angles to one another. By rotation of the eye on its vertical axis the cornea is moved outwards (towards the temple), and inwards (towards the nose): movements called respectively **abduction** and **adduction.** In upward and downward movements of the cornea, the eye rotates on its horizontal equatorial axis. The other principal axis of rotation is the sagittal, which we have previously described as corresponding to the line joining the anterior and posterior poles of the globe (page 843). In rotation of the eye on its sagittal axis, therefore, the cornea may be said to move as a wheel on its axle, for its centre now corresponds to one end of the axis; in other words, this is a **rotation of the cornea.** Such movements may, consequently, be expressed with reference to their effect on an imaginary spoke of the corneal wheel—e.g. one running vertically upwards from the corneal centre. Thus we may say 'rotation of the cornea outwards' when this part of the wheel moves towards the outer canthus, or 'inwards' when towards the nose.

The only two muscles that rotate the eyeball merely on one axis are the **external rectus** and the **internal rectus**; the former abducting, and the latter adducting the cornea.

FIG. 484.—VIEW OF LEFT ORBIT FROM ABOVE, SHOWING THE OCULAR MUSCLES. (From Hirschfeld and Leveillé.)



The chief action of the **superior rectus** is to draw the cornea upwards, but at the same time it adducts and rotates the cornea inwards.

The **inferior rectus** mainly draws the cornea downwards, also adducting it and rotating it outwards.

The chief action of the **superior oblique** is to rotate the cornea inwards, also drawing it downwards and slightly abducting it.

The **inferior oblique** mainly rotates the cornea outwards, also drawing it upwards and slightly abducting it.

The fasciæ of the orbit.—The orbital contents are bound together and supported by fibrous tissues, which are connected with each other, but which may conveniently be regarded as belonging to three systems. These are: (1) Those lining the bony walls; (2) those ensheathing the muscles; and (3) the tissue which partially encapsules the eyeball.

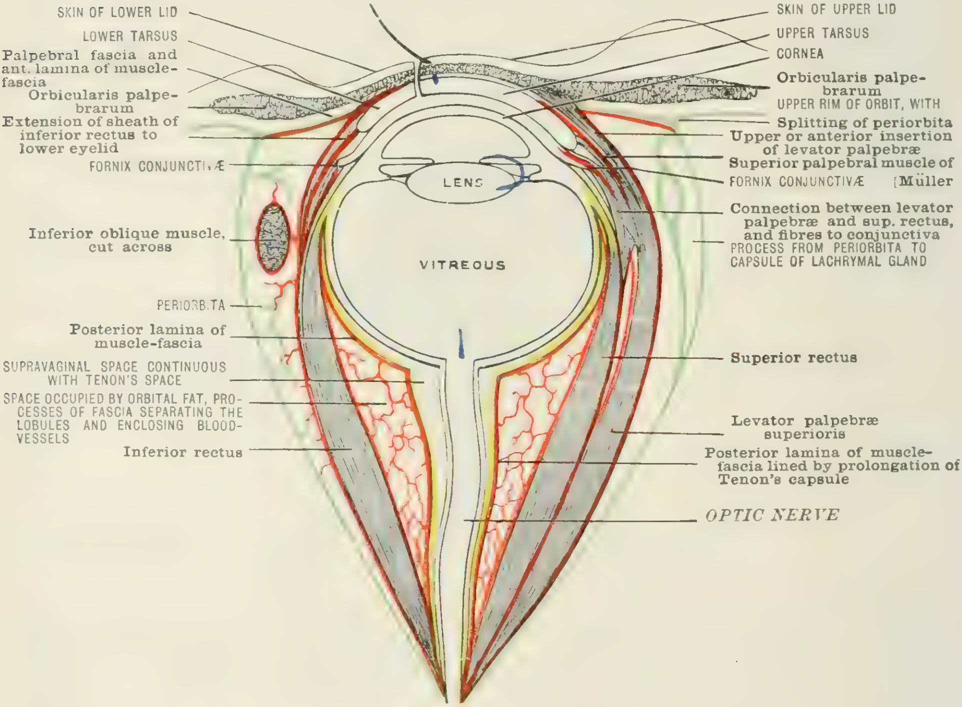
1. The **orbital periosteum,** or **periorbita,** is closely applied to the bones forming the walls of the cavity, but may be stripped off with comparative ease. It presents openings for the passage of vessels and nerves entering and leaving the orbit. Posteriorly this tissue is very firm, being joined by processes of the dura mater at the optic canal and sphenoidal fissure; at the optic foramen it is also

connected with the dural sheath of the optic nerve. As it covers the spheno-maxillary fissure its fibres are interwoven with smooth muscle, forming the **orbital muscle** of Müller. From its inner surface processes run into the orbital cavity, separating the fat lobules. One important process comes from the periorbita about midway along the roof of the orbit, runs forward to the back of the upper division of the lachrymal gland, and there splits, helping to form the gland-capsule: this capsule is joined at its inner border by other periorbital bands coming off near the upper orbital rim, and forming the suspensory ligament of the gland. On the inner side of the orbit the periorbita sends fibrous processes to the trochlea of the superior oblique, which keep it in position. On arriving at the lachrymal groove the periorbita divides into two layers, a thin posterior one continuing to line the bone forming the floor of the groove, whilst the thicker anterior layer bridges over the groove and the sac which lies in it, forming the limbs of the inner palpebral ligament (page 867).

Fig. 485.—Vertical Section through the Eyeball and Orbit in the direction of the Orbital Axis, with Closed Eyelids.

(Semi-diagrammatic. After Schwalbe, modified to show fasciæ.)

Periorbita *green;* muscle-fascia *red;* Tenon's capsule *yellow.*


SKIN OF LOWER LID
LOWER TARSUS
Palpebral fascia and ant. lamina of muscle-fascia
Orbicularis palpebrarum
Extension of sheath of inferior rectus to lower eyelid
FORNIX CONJUNCTIVÆ
Inferior oblique muscle, cut across
PERIORBITA
Posterior lamina of muscle-fascia
SUPRAVAGINAL SPACE CONTINUOUS WITH TENON'S SPACE
SPACE OCCUPIED BY ORBITAL FAT, PROCESSES OF FASCIA SEPARATING THE LOBULES AND ENCLOSING BLOOD-VESSELS
Inferior rectus
LENS
VITREOUS
SKIN OF UPPER LID
UPPER TARSUS
CORNEA
Orbicularis palpebrarum
UPPER RIM OF ORBIT, WITH
Splitting of periorbita
Upper or anterior insertion of levator palpebræ
Superior palpebral muscle of [Müller
FORNIX CONJUNCTIVÆ
Connection between levator palpebræ and sup. rectus, and fibres to conjunctiva
PROCESS FROM PERIORBITA TO CAPSULE OF LACHRYMAL GLAND
Superior rectus
Levator palpebræ superioris
Posterior lamina of muscle-fascia lined by prolongation of Tenon's capsule
OPTIC NERVE

Quite anteriorly, at the rim of the orbit, the periorbita sends off a membranous process which aids in forming the fibrous tissue of the eyelids (**orbito-tarsal ligament,** or **palpebral fascia**), and is itself continuous with the periosteum of the bones outside the orbital margin.

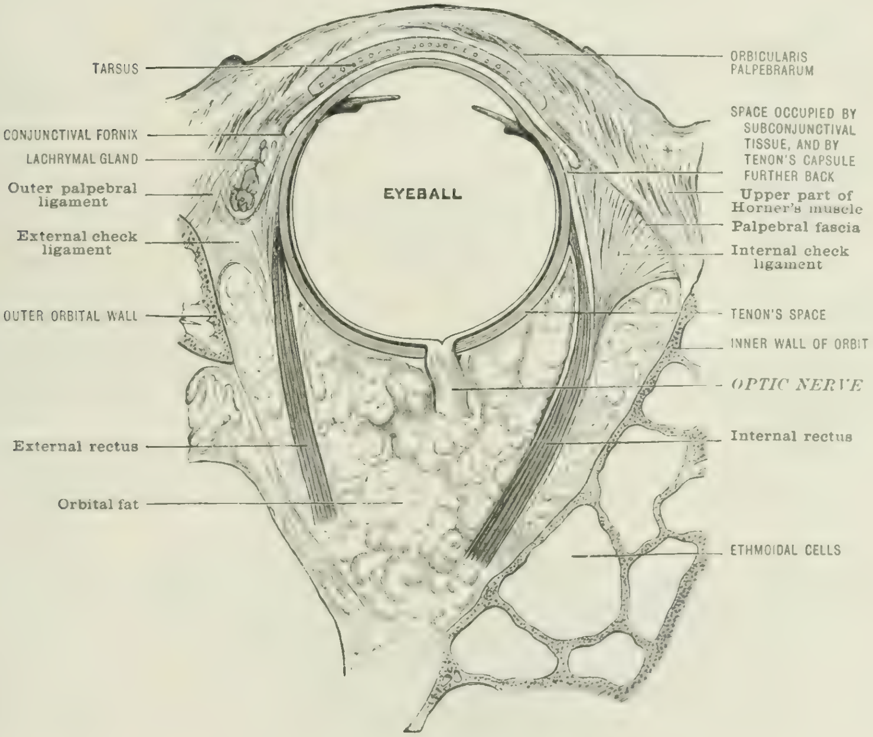
2. The orbital muscles are connected by a common fascia, which splits at their borders and furnishes a sheath to each. Processes of this fascia give membranous investments for the vessels and nerves (including the optic nerve), splitting similarly to enclose them; these membranous processes also assist in separating the fat lobules. Posteriorly, this fascia is thin and loose, and blends with the periorbita at the origin of the muscles. Anteriorly, it becomes thicker and firmer, accompanies the muscles to near the equator of the eyeball, and there divides into two laminæ,

an anterior and a posterior; the former continues a forward course, forming a complete funnel-shaped investment all round, passing ultimately to the eyelids and orbital margin—whilst the latter turns backwards, covering the hinder third of the globe.

The *anterior lamina* is a well-marked membrane everywhere, but in certain situations it presents special bands of thickening, corresponding to the direct continuation forwards of the sheath of each rectus muscle. Above and below, this lamina spreads out in the form of two large membranes, which are finally applied to the deep surface of the palpebral fascia; the lower membrane constitutes what has been described as 'the suspensory ligament of the eyeball.' The upper membrane requires a fuller description, as its distribution is modified by the presence of the levator palpebræ muscle.

The upper part of the sheath of the superior rectus (along with the adjoining membrane on each side of it) passes to the deep surface of the levator, to which it closely adheres, and completely ensheaths this tendon by extending round its borders to its upper surface. The lower part of this levator-sheath is applied to the inferior surface of the deeper of the two divisions of the muscle (*orbito-palpebral muscle* of Sappey, *superior palpebral muscle* of Müller), and is attached to the upper border of the tarsus of the upper lid, reaching laterally to the outer and inner angles of the orbit. The upper part of the sheath of the orbito-palpebralis muscle reaches to the middle of the palpebral fascia, and is mainly continued forward between the muscle and the fascia to the anterior surface of the tarsus.

FIG. 486.—HORIZONTAL SECTION THROUGH LEFT ORBIT, VIEWED FROM ABOVE.
(After Von Gerlach. To show check ligaments, etc.)


TARSUS
CONJUNCTIVAL FORNIX
LACHRYMAL GLAND
Outer palpebral ligament
External check ligament
OUTER ORBITAL WALL
External rectus
Orbital fat
EYEBALL
ORBICULARIS PALPEBRARUM
SPACE OCCUPIED BY SUBCONJUNCTIVAL TISSUE, AND BY TENON'S CAPSULE FURTHER BACK
Upper part of Horner's muscle
Palpebral fascia
Internal check ligament
TENON'S SPACE
INNER WALL OF ORBIT
OPTIC NERVE
Internal rectus
ETHMOIDAL CELLS

The lower membrane (suspensory ligament of the eyeball), joined by the sheath of the inferior rectus, reaches forward to the attached (hinder) border of the tarsus of the lower lid, where it is mainly attached, while a part of it extends to the lower palpebral fascia.

To understand the *special bands* mentioned above, we must follow the sheath of each rectus muscle forwards, when we find that, while it is rather loosely applied to the muscular belly in its posterior two-thirds, it then suddenly becomes thicker, and is firmly attached to the muscle for some distance before finally leaving it, and is thereafter often accompanied by some muscle-fibres. The best developed of these bands, the *external check ligament*, passes forwards and outwards to the outer angle of the orbit, helping to support the lachrymal gland on its way, and is inserted near the orbital edge immediately behind the external palpebral ligament. The inner band, or *internal check ligament*, is larger than the outer, but not so thick; it passes forwards and inwards to be inserted into the upper part of the lachrymal crest and just behind it. These two bands, external and internal, come from the sheaths of the corresponding recti muscles. From the sheath of the superior rectus come two thin bands, one from each border. The inner joins the sheath of the tendon of the superior oblique; the outer goes to the external angle of the orbit, assisting in the support of part of the lachrymal gland. The sheath of the inferior rectus is thickened in front, and, on leaving the muscle, goes to the middle of the inferior oblique, splitting to enclose it; it then passes to be inserted into the lower inner angle of the orbit close behind its margin, about midway between the internal check ligament and the orbital attachment of the inferior oblique.

3. In addition to its partial investment by the muscle-fascia, the eyeball has a special membrane enclosing its hinder two-thirds, usually called **Tenon's capsule.** This is a thin, transparent tissue, situated immediately beneath the muscle-fascia. It follows the curve of the sclerotic from the insertion of the recti to about 3 mm. from the optic nerve entrance, when it leaves the eyeball and blends with the posterior lamina of the muscle-fascia; the combined membrane may be traced backwards, enveloping the optic-nerve sheath loosely, approaching it as it nears the optic foramen, but never actually joining it. The interval between it and the nerve-sheath is called the *supravaginal lymph space.* Tenon's capsule first comes into relation with the muscles at the point where they are left by their proper sheaths; it there invests their tendons, forms a small serous bursa on the anterior surface of each, and adheres to the sclerotic in the form of a line running round the globe, joining the insertions of the four recti muscles. Between this line and the corneal border, the conjunctiva is separated from the sclerotic by the subconjunctival tissue, strengthened by a fine expansion of the muscle-fascia.

The inner surface of the capsule is smooth, and is only connected with the sclerotic by a loose, wide-meshed areolar tissue. This interval between the sclerotic and capsule, known as **Tenon's space,** is a lymph cavity, and permits free movements of the eyeball within the capsule.

Relation of Tenon's Capsule to the Oblique Muscles.—The capsule surrounds the posterior third of the inferior oblique and its tendon, running along its ocular surface till it meets the fascial band coming from the inferior rectus (see above), and forming a serous bursa on the superficial surface of the oblique near its insertion. The tendon of the superior oblique for about its last five millimetres is invested solely by Tenon's capsule; in front of this, as far as the trochlea, the tendon lies in a membranous tube derived from the muscle-fascia, the inner lining of which is smooth, and may be considered as a prolongation of Tenon's capsule.

THE OPTIC NERVE

The part of this nerve with which we have here to do lies within the orbit, extending from the optic foramen to the eyeball. Its course is somewhat **S**-shaped; thus, on entering the orbit, it describes a curve, with its convexity down and out, and then a second slighter curve, convex inwards. Finally, it runs straight forwards to the globe, which it enters to the inner side of its posterior pole. Besides curving as just described, the nerve also rotates on its long axis, so that the surface which is below at the foramen becomes temporal before entering the eyeball.

In its passage through the optic canal the nerve is surrounded by a prolongation of the meninges. The dura mater splits at the optic foramen, part of it joining the periorbita, while the remainder continues to surround the nerve loosely as its outer or **dural sheath.** The nerve is closely enveloped by a vascular covering derived from the pia mater, named accordingly the **pial sheath.** The space between these two sheaths, known as the *intervaginal space*, is subdivided by a fine prolongation of the arachnoid (the **arachnoidal sheath**) into two parts, viz. an outer, narrow, *subdural*, and an inner, wider, *subarachnoid space*, communicating with the corresponding intracranial spaces. The arachnoidal sheath is connected with the sheath on each side of it by numerous fine processes which bridge across the intervening spaces. The pial sheath sends processes inwards, which form a framework separating the bundles of nerve-fibres; between the enclosed nerve-fibres and each mesh of this framework there is a narrow interval occupied by lymph. The nerve-fibres are medullated, but have no primitive sheath. About fifteen or twenty millimetres behind the globe the central vessels enter, piercing obliquely the lower outer quadrant of the nerve, and then run forward in its axis. They are accompanied throughout by a special process of the pial sheath, which forms a fibrous cord in the centre of the nerve.

FIG. 487.—TRANSVERSE SECTION THROUGH OPTIC NERVE, SHOWING THE RELATIONS OF ITS SHEATHS AND CONNECTIVE TISSUE FRAMEWORK.

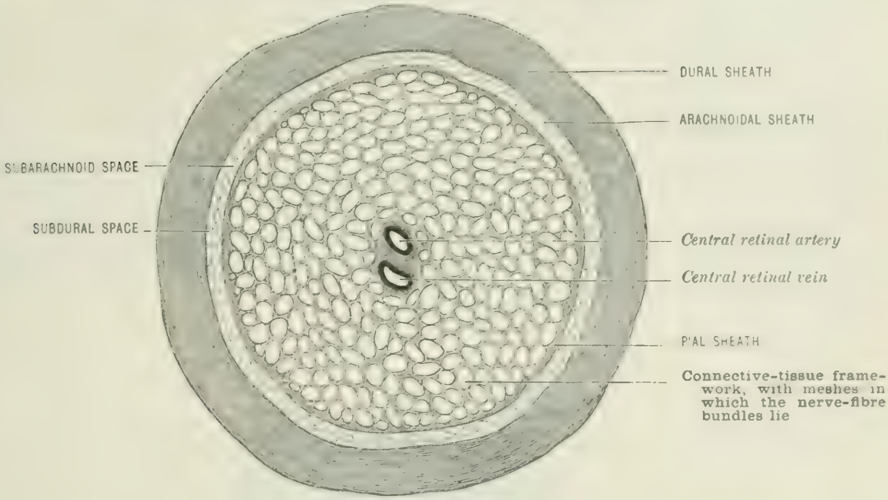
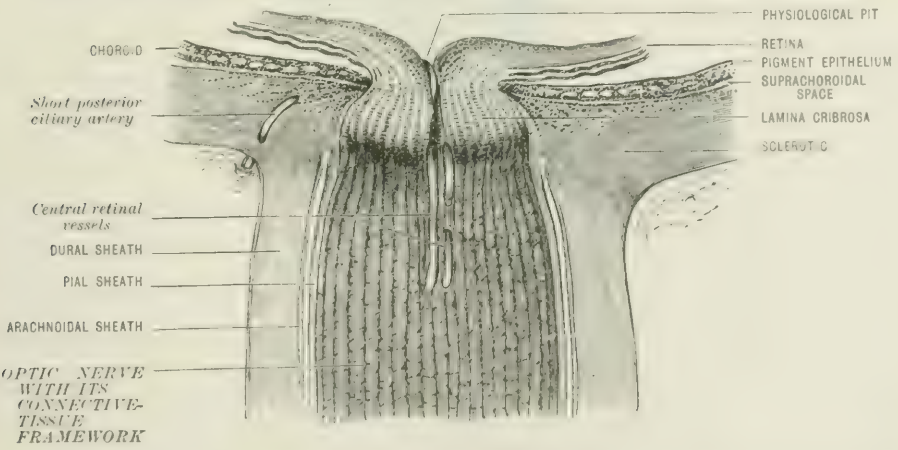

DURAL SHEATH
ARACHNOIDAL SHEATH
SUBARACHNOID SPACE
SUBDURAL SPACE
Central retinal artery
Central retinal vein
PIAL SHEATH
Connective-tissue framework, with meshes in which the nerve-fibre bundles lie

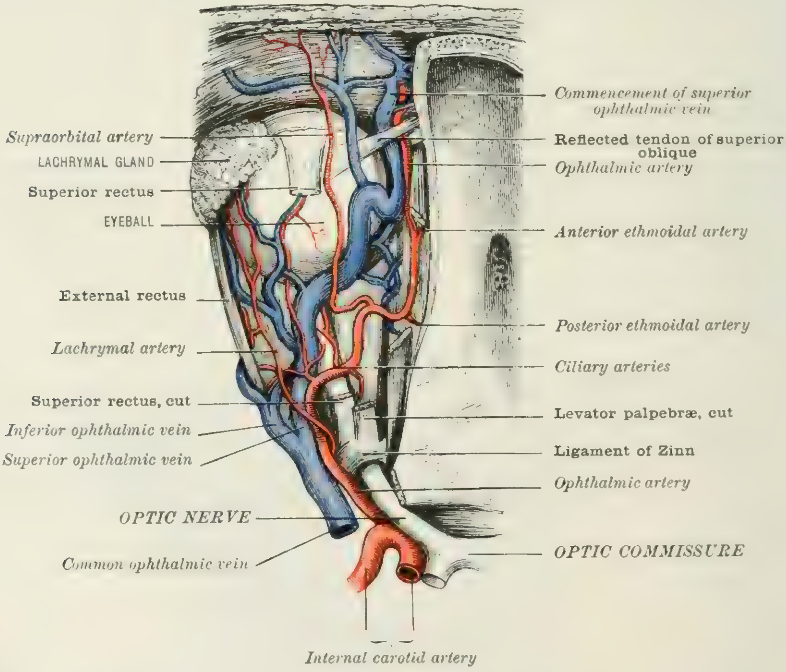
FIG. 488.—LONGITUDINAL SECTION THROUGH TERMINATION OF OPTIC NERVE.


PHYSIOLOGICAL PIT
CHOROID
RETINA
PIGMENT EPITHELIUM
SUPRACHOROIDAL SPACE
Short posterior ciliary artery
LAMINA CRIBROSA
SCLEROTIC
Central retinal vessels
DURAL SHEATH
PIAL SHEATH
ARACHNOIDAL SHEATH
OPTIC NERVE WITH ITS CONNECTIVE-TISSUE FRAMEWORK

On reaching the eyeball, the dural sheath is joined by the arachnoid, and turns away from the nerve to be continued into the outer two-thirds of the sclerotic. Similarly the pial sheath also here leaves the nerve, its greater part running into the inner third of the sclerotic, while a few of its fibres join the choroid; the intervaginal space consequently ends abruptly in the sclerotic around the nerve-entrance. In this locality the connective-tissue framework of the nerve becomes thicker and closer in its meshwork, and has been already alluded to as the **lamina cribrosa.** It is formed by processes passing out from the central fibrous cord at its termination, and by processes passing inwards from the pial sheath, sclerotic, and choroid. It does not pass straight across the nerve, but follows the curve of the surrounding sclerotic, being therefore slightly convex backwards. The nerve-trunk here quickly becomes reduced to one-half its former diameter, the fibres losing their medullary sheath, and being continued henceforward as mere axis cylinders. Apart from the consequent loss of bulk, this histological change may be readily recognised macroscopically in a longitudinal section of the nerve, its aspect here changing from opaque white to semi-translucent grey. The part of the nerve within the lamina cribrosa has already been seen in our ophthalmoscopic examination of the living eye.

The optic nerve is mainly nourished by fine vessels derived from those of the pial sheath, which run into the substance of the nerve in the processes above mentioned. In front of the entrance of the central retinal artery this vessel aids to some extent in the blood-supply of the axial part of the nerve.

FIG. 489.—THE BLOOD-VESSELS OF THE LEFT ORBIT, VIEWED FROM ABOVE.


Commencement of superior ophthalmic vein
Supraorbital artery
Reflected tendon of superior oblique
LACHRYMAL GLAND
Ophthalmic artery
Superior rectus
EYEBALL
Anterior ethmoidal artery
External rectus
Posterior ethmoidal artery
Lachrymal artery
Ciliary arteries
Superior rectus, cut
Levator palpebræ, cut
Inferior ophthalmic vein
Ligament of Zinn
Superior ophthalmic vein
Ophthalmic artery
OPTIC NERVE
OPTIC COMMISSURE
Common ophthalmic vein
Internal carotid artery

THE BLOOD-VESSELS AND NERVES OF THE ORBIT

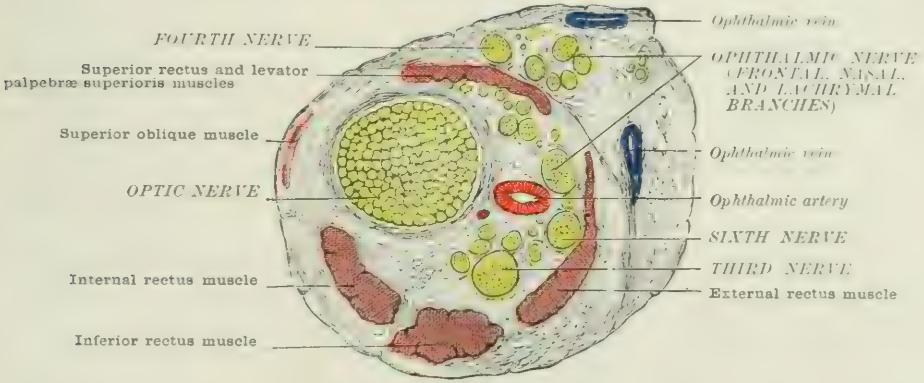
As these structures will be more particularly described in other sections of this work, a very short general account will suffice here.

Arteries.—The main blood-supply is afforded by the **ophthalmic artery,** a branch of the internal carotid, which gains the orbit through the optic canal, where it lies beneath and to the temporal side of the nerve. On entering the orbit it ascends, and passes obliquely over the optic nerve to the inner wall of the orbit; in this early part of its course it gives off most of its branches, which vary much in their manner of origin and also in their course. The arteries of the orbit are remarkable for their tortuous course, for their delicate walls, and for their loose attachment to the surrounding tissues. The ophthalmic artery gives off special branches in the orbit to the lachrymal gland, the muscles, the retina (through the optic nerve), and the eyeball, as well as to the meninges, the ethmoidal cells, and the nasal mucous membrane. Twigs from all the different branches go to supply the fat, fasciæ, and ordinary nerves of the orbit. Branches which leave the orbit anteriorly ramify on the forehead and nose, and also go to the supply of the eyelids and the tear-passages. The ophthalmic artery has many anastomoses with branches of the external carotid. The contents of the orbit are also supplied in part by the **infraorbital artery,** a branch of the internal maxillary; in particular this artery supplies part of the inferior rectus and inferior oblique muscles in the cavity, and also gives a branch to the lower eyelid.

Veins.—Branches, corresponding generally to those of the artery, unite to form the **superior** and **inferior ophthalmic veins,** which ultimately, either separately or united into one trunk, pass through the sphenoidal fissure and empty into the cavernous sinus. The inferior vein is connected with the pterygoid plexus by a branch which leaves the orbit by the spheno-maxillary fissure.

Nerves of the orbit.—These are **motor, sensory,** and **sympathetic,** and all enter the orbit by the sphenoidal fissure, with the exception of one small sensory branch passing through the spheno-maxillary fissure. (The optic nerve has been already described, and is not included in this account.)

FIG. 490.—SECTION THROUGH CONTENTS OF RIGHT ORBIT, 1–2 MM. IN FRONT OF THE OPTIC FORAMEN, VIEWED FROM BEHIND. (After Lange.)



A. The **motor nerves** are the third, fourth, and sixth cranial.

1. The **third nerve** enters the orbit in two parts, an upper smaller, and a lower larger division. The *upper division* gives off two branches: one supplies the superior rectus, entering its lower surface far back; the other branch goes to the levator palpebræ, entering its lower surface in its posterior third. The *lower division* divides into three branches, of which one supplies the inferior rectus, entering its upper surface far back, and another supplies the internal rectus, entering its inner surface a little behind its middle. The third branch of the lower division gives (1) the short root to the ciliary ganglion, and (2) one or more twigs to the inferior rectus, and the remainder of this branch then enters the lower surface of the inferior oblique muscle about its middle.

2. The **fourth nerve** supplies the superior oblique muscle, entering its upper surface about midway in its course.

3. The **sixth nerve** supplies the external rectus, entering its inner surface about the junction of the posterior and middle thirds of the muscle.

As regards the manner of termination of these motor nerves, it is found that in all the ocular muscles the nerve on its entrance breaks up into numerous bundles of fibres, which form first coarse and then fine plexuses, the latter ultimately sending off fine twigs supplying the muscle throughout with nerve-endings. The *posterior third* of these muscles is, however, comparatively ill supplied with both kinds of plexus and with nerve-endings.

B. The **sensory nerves** are supplied by the first and second divisions of the fifth cranial nerve. The first division, or ophthalmic nerve, is entirely orbital; while the second, or maxillary, only sends a small branch to the orbit.

1. The **ophthalmic division of the fifth nerve** enters the orbit in three divisions, namely:—

(1) **Frontal,** splitting subsequently into *supratrochlear* and *supraorbital*, both passing out of the orbit. It is distributed to the corresponding upper eyelid, and the skin over the root of the nose, the forehead, and the hairy scalp as far back as the coronal suture on the same side. It also gives branches to the periosteum in this region, and to the frontal sinus.

(2) **Lachrymal,** supplying the lachrymal gland, anastomosing with a branch of the superior maxillary in the orbit, and finally piercing the upper eyelid. Outside the orbit it is distributed to the outer part of the upper lid, the conjunctiva at the external canthus, and the skin between this and the temporal region.

(3) **Nasal,** giving off (*a*) a branch to the ciliary ganglion, constituting its long root; (*b*) two or three *long ciliary nerves;* and (*c*) the *infratrochlear*, passing out of the orbit. The nasal nerve then leaves the orbit, re-entering the cranial cavity before being finally distributed to the nose. The infratrochlear branch supplies the eyelids and skin of the side of the nose near the inner canthus, the lachrymal sac, caruncle, and plica semilunaris. The nasal nerve, after its second course in the cranial cavity, passes through an aperture in the front of the cribriform plate of the ethmoid bone, and is ultimately distributed to the nasal mucous membrane, and to the skin of the side and ridge of the nose near its tip.

2. The **maxillary division of the fifth nerve** gives a branch, called the **orbital nerve,** which passes into the orbit through the spheno-maxillary fissure, anastomoses with the lachrymal, and leaves the orbit in two divisions. These are distributed to the skin of the temple and of the prominent part of the cheek.

A few minute twigs from Meckel's ganglion, and sometimes from the maxillary division of the fifth nerve, also pass through the spheno-maxillary fissure to supply the periorbita in this neighbourhood.

C. The **sympathetic nerves of the orbit** are derived from the plexus on the internal carotid. With the exception of branches accompanying the ophthalmic artery, and of the distinct sympathetic root of the ciliary ganglion, they enter the orbit in the substance of the other nerve-cords. The connections between the ocular nerves and the carotid plexus are recognisable as fibres going to the third, sixth, and ophthalmic nerves; as a rule, the comparatively large twigs going to the sixth join it furthest back, and those to the third furthest forward. Sympathetic connections with the fourth nerve are very doubtful.

The **lenticular** or **ciliary ganglion** is situated between the optic nerve and external rectus far back in the orbit. Its three roots—motor, sensory, and sympathetic—have been already mentioned. Anteriorly, it gives off three to six small trunks, which subdivide to form the **short ciliary nerves,** about twenty in number, piercing the sclerotic around the optic nerve entrance.

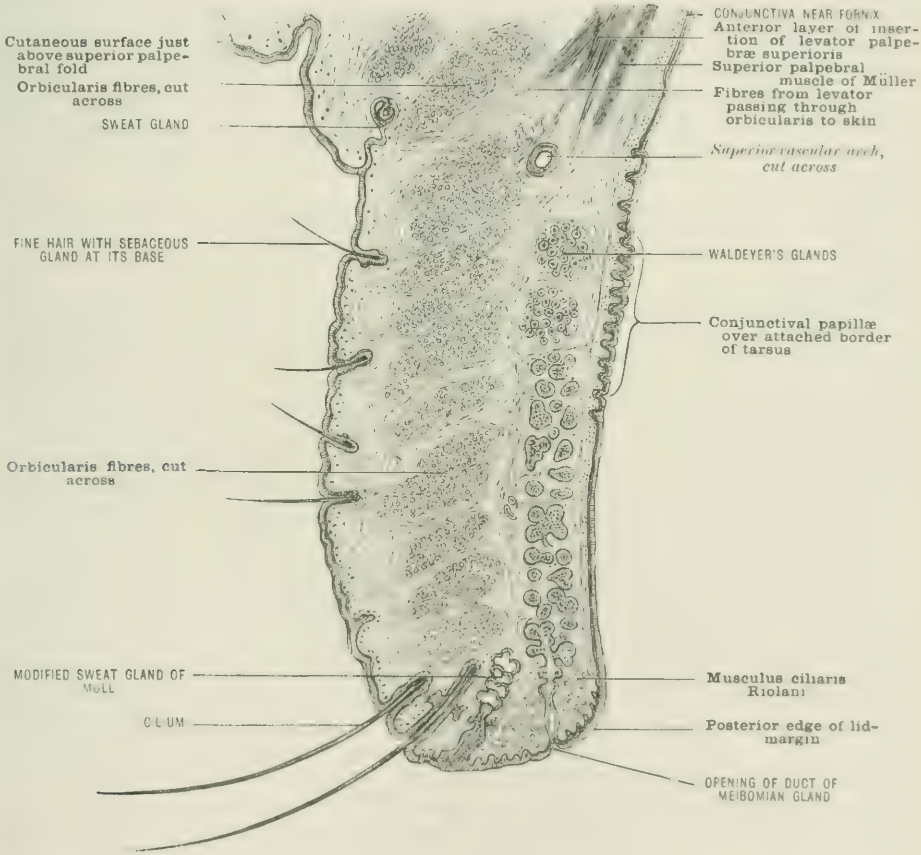
The lymphatic system of the orbit.—Although there are no lymphatic *vessels* or *glands* in the orbit, the passage of lymph is nevertheless well provided for. We have already observed the lymph channels within, between, and outside the sheaths of the optic nerve, and have seen how these communicate anteriorly with the lymph channels of the eyeball, and posteriorly with the intracranial meningeal spaces. In addition, there are lymph-spaces around the blood-vessels, situated between the outer coat and the loose investment furnished by the muscle-fascia. The nerves of the orbit (apart from the optic) are probably similarly surrounded by lymph-spaces. In the absence of lymphatic vessels it is difficult to trace the circulation thoroughly; much of the lymph from the orbital cavity is said to pass into the internal maxillary glands.

THE EYELIDS

The cutaneous and conjunctival surfaces of the lids have already been examined, and the position of the tarsus has been indicated. We have now to ascertain the nature and relations of the tarsus, and describe the other tissues entering into the formation of the eyelids.

The skin here is thin, bearing fine hairs, and having small sebaceous and numerous small sweat glands. Immediately beneath it is a loose subcutaneous tissue, destitute of fat, separating the skin from the palpebral part of the **orbicularis muscle.** The lid-fibres of this muscle arise from the inner palpebral ligament, and course over the whole upper and lower eyelids in a succession of arches, so as to meet again beyond the outer canthus: there they in part join one another, in part are inserted into the outer palpebral ligament. The muscular fibres are arranged in loose bundles, with spaces between them occupied by connective tissue: in the upper lid these connective-tissue fibres may be traced upwards and backwards into the fibrous expansion of the tendon of the levator palpebræ superioris. One strong bundle of orbicularis fibres, called the **musculus ciliaris Riolani**, is found near the edge of the lid, in front of, and behind, the efferent ducts of the Meibomian **glands.**

FIG. 491.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER EYELID. (After Waldeyer and Fuchs.)


Cutaneous surface just above superior palpebral fold
Orbicularis fibres, cut across
SWEAT GLAND
FINE HAIR WITH SEBACEOUS GLAND AT ITS BASE
Orbicularis fibres, cut across
MODIFIED SWEAT GLAND OF MOLL
CILIUM
CONJUNCTIVA NEAR FORNIX
Anterior layer of insertion of levator palpebræ superioris
Superior palpebral muscle of Müller
Fibres from levator passing through orbicularis to skin
Superior vascular arch, cut across
WALDEYER'S GLANDS
Conjunctival papillæ over attached border of tarsus
Musculus ciliaris Riolani
Posterior edge of lid-margin
OPENING OF DUCT OF MEIBOMIAN GLAND

A **central connective tissue** separates the orbicularis muscle from the tarsus in the tarsal division of the lids. In the upper lid this is to be regarded as mainly the anterior or fibrous expansion of the tendon of the levator palpebræ, which

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sends connective-tissue septa between the bundles of the overlying orbicularis (as just mentioned) going to the skin. In the orbital part of this lid the central connective tissue includes also the palpebral fascia, lying here immediately beneath the orbicularis muscle; but this soon thins off and fades into the more deeply placed levator expansion. This latter is strengthened by an extension of the sheath of the superior rectus, by which this muscle is enabled to influence the elevation of the lid indirectly. In the lower lid the central connective tissue similarly consists of palpebral fascia, blended with a thin fibrous extension of the sheath of the inferior rectus. Immediately in front of each tarsus is a little loose connective tissue, which contains the large blood-vessels and nerves of the lids.

The **tarsus** of each lid is a stiff plate of close connective tissue, with its surfaces directed anteriorly and posteriorly; in its substance the Meibomian glands are embedded. One tarsal border is free, viz. towards the edge of the lid, the other is attached; the former is straight, while the latter is convex, especially in the upper lid. The length of each tarsus is about twenty millimetres. Its breadth is greatest in the middle of the lid, and becomes gradually smaller towards each canthus, where the tarsi are joined to the outer and inner palpebral ligaments. The breadth of the upper tarsus (10 mm.) is about twice that of the lower. The thickness of each is greatest, and its texture closest, at the middle of its length, thinning off towards the canthi and towards both borders. Into the superior anterior border of the upper tarsus the lower layer of the levator expansion is attached, consisting of smooth muscle-fibres constituting the **superior palpebral muscle** of Müller. In like manner, at the inferior border of the lower tarsus, bundles of smooth muscle fibre are inserted (the **inferior palpebral muscle** of Müller), developed in what has been regarded as part of the extension of the sheath of the inferior rectus.

The **palpebral conjunctiva** is firmly adherent to the back of the tarsus; but in the orbital part of the lid loose subconjunctival tissue intervenes between it and Müller's palpebral muscle. Adenoid tissue occurs in the substance of the conjunctiva, especially in its orbital division. Near the upper fornix, the conjunctiva receives expansions of the tendon of the levator palpebræ and of the sheath of the superior rectus, and, at the lower fornix, of the sheath of the inferior rectus. The surface of the tarsal conjunctiva shows small elevations or papillæ everywhere; but these are particularly well marked over the attached border of the tarsus.

Glands of the eyelids.—From its manner of formation the eyelid may be regarded as consisting of two thicknesses of skin, the inner (or posterior) having been doubled back upon the outer at the edge of the lid; thus the cuticle and corium of the skin proper are represented respectively by the conjunctiva and tarsus of the inner thickness. At the free border of the lid, accordingly, we find glands corresponding to the sebaceous and sweat glands of the skin, viz. large sebaceous glands of the cilia (Zeiss's glands) and Moll's modified sweat glands. Again, in the inner skin-thickness of the lid, the Meibomian glands of the tarsus are sebaceous, and acino-tubular glands present at the attached border of the tarsus (Waldeyer's glands) may be reckoned as modified sweat glands. Glands similar in structure to Waldeyer's also occur at the fornix, and are especially abundant near the outer canthus of the upper lid, close to the efferent ducts of the lachrymal gland; from their structure, and the character of their secretion, these acinous or acino-tubular glands have been termed by Henle 'accessory lachrymal glands.' Other simple tubular glands (Henle), formed merely by the depressions between the papillæ, are best developed in the inner and outer fourths of the tarsal conjunctiva of both lids.

Blood-vessels.—The arteries run in the central connective tissue of the lids, mainly in the form of arches near the borders of the tarsus, from which twigs go to the different palpebral tissues. They are supplied by the lachrymal and palpebral branches of the ophthalmic, and by small branches derived from the temporal artery. The veins are more numerous and larger than the arteries, and form a close plexus beneath each fornix. They empty themselves into the veins of the face at the inner, and into the orbital veins at the outer canthus.

The **lymphatic vessels of the lids** are numerous, and are principally situated in the conjunctiva. Lymph-spaces also surround the follicles of the Meibomian glands. The palpebral lymphatic vessels mainly pass through the preauricular gland; but, sometimes at least, those from the inner half of the lower lid go to the submaxillary lymphatic glands.

Nerves.—(*a*) **Sensory.** The upper lid is chiefly supplied by branches of the supraorbital and supratrochlear nerves, the lower lid by one or two branches of the infraorbital. At the inner canthus the infratrochlear nerve also aids in the supply, and, at the outer canthus, the lachrymal. (*b*) **Motor.** The palpebral part of the orbicularis is supplied by branches of the facial nerve, which mainly enter it near the outer canthus. Müller's palpebral muscles are supplied by the sympathetic nervous system.

The **inner palpebral ligament,** or **tendo oculi,** has been referred to previously. Arising from the frontal process of the maxilla, it extends outwards over the front wall of the lachrymal sac, bends round the outer wall of the sac, and then passes backwards to the posterior crest on the lachrymal bone. It is thus U-shaped, having its limbs anterior and posterior, embracing the lachrymal sac; the anterior limb lies immediately beneath the skin, and is visible in the living. The palpebral fibres of the orbicularis are inserted into the outer surface of both limbs, those attached to the posterior limb constituting **Horner's muscle.** The **outer palpebral ligament** is merely a stronger development of connective tissue in the orbicularis. Both ligaments are connected with the tarsi as already mentioned.

THE LACHRYMAL APPARATUS

The tears are secreted by an acinous gland, and flow through fine ducts to the upper outer part of the conjunctival sac, whence they are drained off through the puncta, pass along the canaliculi into the lachrymal sac, and ultimately run down the nasal duct to gain the inferior meatus of the nose.

The **lachrymal gland** is situated near the front of the outer part of the roof of the orbit, lying in a depression in the orbital plate of the frontal bone. It consists of two very unequal parts, one placed above and the other beneath the tendinous expansion of the levator palpebræ superioris, but small gaps in the expansion permit of connections between these two parts of the gland. The upper and larger subdivision (*superior lachrymal gland*) is a firm elongated body, about the size of a small almond; it has a greyish-red colour, and is made up of closely aggregated lobules. The upper surface (next the orbital roof) is convex, and its lower surface is slightly concave. Anteriorly, the gland almost reaches the upper orbital margin, and it extends backwards for approximately one-fourth the depth of the orbit, measuring about twelve millimetres in this direction. The outer border of the gland descends to near the insertion of the fascial expansion of the external rectus, while its inner border almost reaches the outer edge of the superior rectus; its transverse measurement is about twenty millimetres. It is enveloped in a capsule, which is slung by strong fibrous bands passing to its inner border from the orbital margin (suspensory ligament of the gland).

The lower subdivision of the gland (*inferior lachrymal gland*) is composed of loosely applied lobules, and lies immediately over the outer third of the upper conjunctival fornix, reaching outwards as far as the external canthus.

Each subdivision of the gland possesses several excretory ducts, which all open on the outer part of the upper fornix conjunctivæ, about four millimetres above the upper border of the tarsus. Those of the superior gland, three or four in number, pass between the lobules of the lower gland; the outermost duct is the largest, and opens at the level of the external canthus. The ducts of the inferior gland in part discharge themselves into those of the upper, but there are also several fine ducts from this subdivision that run an independent course.

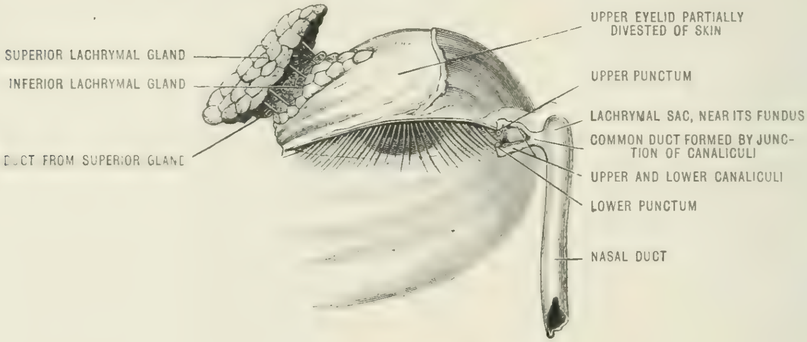
Near the inner canthus are the two **puncta lachrymalia,** upper and lower, each situated at the summit of its papilla. The top of each papilla curves backwards towards the conjunctival sac, so that the puncta are well adapted for their function of draining off any fluid collecting there.

The **canaliculi lachrymales** extend from the puncta to the lachrymal sac. The lumen at the punctum is horizontally oval, from its lips being slightly compressed antero-posteriorly; the lumen of the lower punctum is somewhat larger than that of the upper. As the lower papilla is a little further from the inner canthus than the upper, the corresponding canaliculus is longer.

On tracing either canaliculus from its origin, we find that at first it runs nearly vertically for a short distance, then bends sharply towards the nose, and finally courses more or less horizontally, converging slightly towards its fellow, and not infrequently joining it before opening into the sac. The calibre varies considerably in this course, being narrowest a short distance from the punctum, and widest at the bend, from which point it again narrows very gradually as it nears the sac. The wall of the canaliculus consists mainly of elastic and white fibrous tissue, lined internally by epithelium, and covered externally by striated muscle (part of the orbicularis). The muscle-fibres run parallel to the canaliculus in the horizontal part of its course; but they are placed, some in front and some behind, around the vertical part, acting here as a kind of sphincter. Just before their termination, the canaliculi pierce the periosteal thickening that constitutes the posterior limb of the inner palpebral ligament.

The **lachrymal sac** lies in a depression in the bone at the inner angle of the orbit (the lachrymal fossa). It is vertically elongated, and narrows at its upper and lower ends; the upper extremity or *fundus* is closed, while the lower is continuous directly with the nasal duct. Laterally, the sac is somewhat compressed, so that its antero-posterior is greater than its transverse diameter. The canaliculi, either separately or by a short common tube, open into a bulging on the outer surface of the sac near the fundus. As has previously been mentioned, the sac is surrounded by periosteum, but between this and the mucous membrane forming the true sac-wall there is a loose connective tissue, so that the cavity is capable of considerable distension. The relations of the inner palpebral ligament have already been described; it is to be noted that the fundus of the sac extends above this ligament.

Fig. 492.—Lachrymal Apparatus. (After Schwalbe.)


SUPERIOR LACHRYMAL GLAND
INFERIOR LACHRYMAL GLAND
DUCT FROM SUPERIOR GLAND
UPPER EYELID PARTIALLY DIVESTED OF SKIN
UPPER PUNCTUM
LACHRYMAL SAC, NEAR ITS FUNDUS
COMMON DUCT FORMED BY JUNCTION OF CANALICULI
UPPER AND LOWER CANALICULI
LOWER PUNCTUM
NASAL DUCT

The **nasal duct** reaches from the lower end of the sac to the top of the inferior meatus of the nose, opening into the latter just beneath the adherent border of the inferior turbinated bone. Traced from above, its main direction is downwards, but it has also a slight inclination backwards and outwards. It lies in a bony canal, whose periosteum forms its outer covering. Between this and the mucous membrane of the duct there is a little intermediate tissue, in which run veins of considerable size connected with the plexus of the inferior turbinated bone. The duct does not usually open directly into the nasal cavity at the lower end of the bony canal, but pierces the nasal mucous membrane very obliquely, so that a *flap* of mucous membrane covers the lower border of the opening in the bone, upon which flap the tears first trickle after escaping from the duct proper.

The sac and nasal duct together constitute the **lachrymal canal**, lined throughout by a continuous mucous membrane. This membrane presents folds in some situations, especially near the opening of the canaliculi, at the junction of the sac and duct, and at the lower end of the duct. That at the top of the duct is the most important, as it sometimes interferes with the proper flow of tears out of the sac. The total length of the lachrymal canal is roughly twenty-four millimetres, half of this being sac, and half nasal duct. If, however, we reckon as duct the oblique passage through the nasal mucous membrane, this measurement may occasionally be increased by eight or ten millimetres. The lachrymal sac, when distended, measures about six millimetres from before backwards, by four millimetres transversely. The nasal duct is practically circular, and has a diameter of about three millimetres, rather less at its junction with the sac, where we find the narrowest part of the whole lachrymal canal.

THE EAR

By ARTHUR HENSMAN, F.R.C.S.

Revised by ARTHUR ROBINSON, M.D., M.R.C.S.

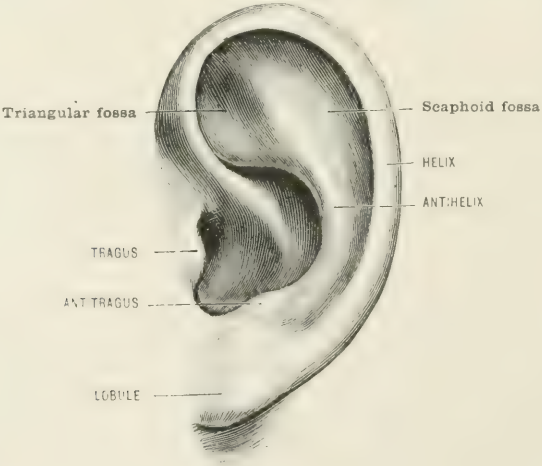
LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL. EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

The organ of hearing may be divided into three parts:—the **EXTERNAL EAR**, which includes the **pinna** and **external auditory meatus**; the **MIDDLE EAR**, or **tympanum**, with its ventilating shaft the **Eustachian tube**; and the **INTERNAL EAR**, which includes the **osseous labyrinth**, within which is placed—the essential portion of the organ—the **membranous labyrinth.**

THE EXTERNAL EAR

The **Pinna**, or **Auricle**, is attached to the side of the head, midway between the forehead and occiput. Its level is indicated by horizontal lines extending backwards from the eyebrows above, and from the tip of the nose below. Somewhat pyriform in shape, its irregular concave outer surface is turned more or less forwards, but the angle of inclination varies considerably in different subjects. The incurved rim of the ear, which divides its surfaces from each other, commences below in a deep concavity which surrounds, like the mouth of a trumpet, the external auditory meatus. This rim is called the **helix**, and, traced round the

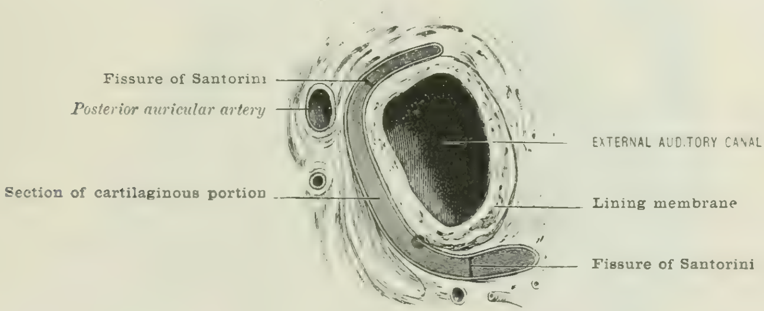
Fig. 493.—External View of the Left Auricle.



ear, ends below at the posterior margin of the **lobule.** On the upper part of the inverted edge of the helix a little irregular process often exists, which has been regarded as the shrivelled tip of the primitive ear, and anteriorly, where it begins to bend backwards, there is a small projection, the spine of the helix (Fig. 495). The hollow from which the helix starts is called the **concha.** Within the helix, but separated from it by the **scaphoid fossa** (fossa of the helix) runs a second curved ridge, the **antihelix.** It commences below in the little process known as the **antitragus,** and bifurcating superiorly bounds a shallow fossa just above the concha, the so-called **triangular fossa** (fossa of the antihelix). The concha, bounded by the antihelix, is deeply notched below (incisura intertragica). Overlapping the commencement of the notch before and behind are two eminences, the anterior and larger, the **tragus**; the posterior, the **antitragus.** The auricle varies greatly in different individuals, and the lobule perhaps more than any other part.

The **cartilaginous framework** of the ear, although it does not enter into all its parts, gives to it the general character and appearance already described. It consists of pliable reticular cartilage of the yellow elastic kind. It does not enter into the formation of the **lobule,** which consists entirely of dense connective tissue and fat. Its lower portion is so rolled upon itself as to form a tube incomplete above, which tails off as it passes inwards to be attached to the lower third of the external auditory meatus. This attachment is effected by means of a dense fibro-elastic tissue which allows considerable shifting on traction of the pinna upwards and backwards. A section passing through the orifice of the meatus shows the cartilage greatly in excess of the fibrous membrane which completes its contour. Deeper sections show the cartilage diminishing more and more until it forms scarcely a third of the lumen of the tube near the bony meatus.

FIG. 494.—SECTION THROUGH THE ORIFICE OF THE RIGHT EXTERNAL AUDITORY MEATUS.



The wall of the channel is traversed by fissures, the **fissures of Santorini**; but these are not constant in their number, extent, or direction; they are filled with fibrous tissue, and allow the canal to be straightened by traction on the pinna. The lower segment of the cartilaginous meatus is in close contact with the parotid gland. An abscess in this region may thus burrow through the fissures and discharge itself through the external meatus. There is also a gap between the helix and the tragus bridged over by a band of dense fibrous tissue. Several fissures traverse the cartilage, and a deep cleft dividing the antihelix severs the caudate process from the rest of the cartilage below.

Ligaments.—An **anterior ligament** connects the spine of the helix with the root of the zygoma, and a **posterior** passes from the concha to the mastoid process.

A pair of ligaments belong to the cartilage itself, the strong band already described completing the orifice of the meatus, and one less marked passing between the concha and the processus caudatus.

Muscles.—The **extrinsic muscles,** the attollens, attrahens, and retrahens aurem, have been described on page 431. The special intrinsic muscles are six in number. They are difficult to display, and sometimes appear to be absent.

Helicis major is a narrow slip which arises from the spine of the helix and passes upwards along the rim of the helix to near its summit.

Helicis minor is an oblique fasciculus overlying the commencement of the helix.

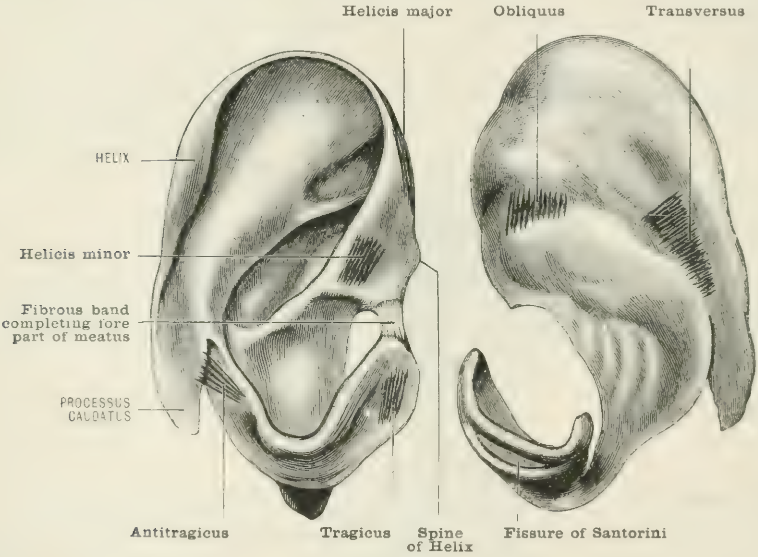
The **tragicus** consists of nearly vertical fibres lying over the outer surface of the tragus.

The **antitragicus** arises from the outer surface of the antitragus to pass to the caudate process.

The **transversus auris** consists of mixed muscular and tendinous fibres which with the following lies on the cranial aspect of the pinna, and traverses the hollow formed between the bulging of the concha and the convexity corresponding to the groove of the helix.

The **obliquus auris** crosses the hollow between the concha and fossa of the antihelix.

Fig. 495.—External and Internal Surface of the Cartilage of the Right Pinna and its Muscles, etc.



Vessels.—The **arteries** are the **posterior auricular** from the external carotid, and the **anterior auricular** from the temporal.

The **veins** enter the posterior auricular and temporal veins.

Nerves.—The inner surface of the pinna is supplied by three cutaneous nerves, the great auricular, the small occipital and the auricular branch of the vagus. The great auricular supplies the lower three-quarters, with the exception of a small portion near the meatus which, together with the back of the meatus, is supplied by the auricular branch of the vagus. The small occipital supplies the upper fourth. Occasionally the great occipital sends a branch to the uppermost part of the inner surface. The upper two-thirds of the outer surface receive their cutaneous supply from the auriculo-temporal nerve, and the lower third is supplied by the great auricular. The intrinsic muscles on the inner surface are supplied by the posterior auricular branch of the facial and those on the outer surface by the temporal branch of the same nerve.

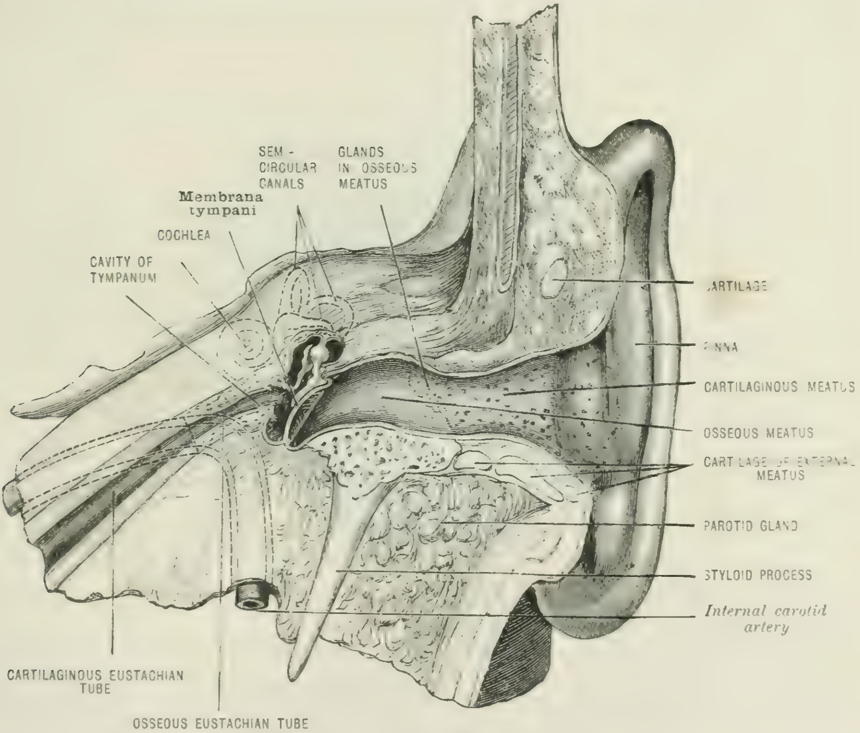
The **External Auditory Meatus** is about an inch long (25 mm.). It commences at the bottom of the concha, and passes inwards and a little forwards to end at the membrana tympani. It is narrowest at its centre. Near its orifice it is oval from above downwards, but at its termination it is somewhat broader from side to side. Owing to the obliquity of the membrana tympani, the floor is longer than the roof, and the anterior longer than the posterior wall of the canal.

Its **cartilaginous portion,** which is a little less than half an inch (11 mm.) in length, is formed by the incomplete tube of cartilage already described, with fibrous membrane to complete its upper and front part.

The **osseous portion** of the tube, a little more than half an inch (14 mm.) in length, is slightly curved, with its convexity looking upwards and backwards (fig. 496).

The **lining membrane** is a reflexion from the skin externally. It is thick and strong in the cartilaginous, but becomes thinner in the osseous portion; especially is this the case near the membrana tympani, over which it is reflected to form its cuticular layer. In the cartilaginous portion the dermis is supplied with numerous hairs, and sebaceous glands open into their follicles. Tubular ceruminous glands, the orifices of which stud the whole of the cartilaginous portion, appear as dark points to the naked eye.

FIG. 496.—SECTION OF THE MIDDLE AND EXTERNAL EAR.


SEMI-CIRCULAR CANALS
GLANDS IN OSSEOUS MEATUS
Membrana tympani
COCHLEA
CAVITY OF TYMPANUM
CARTILAGE
PINNA
CARTILAGINOUS MEATUS
OSSEOUS MEATUS
CARTILAGE OF EXTERNAL MEATUS
PAROTID GLAND
STYLOID PROCESS
Internal carotid artery
CARTILAGINOUS EUSTACHIAN TUBE
OSSEOUS EUSTACHIAN TUBE

These glands extend a short distance into the upper and back part of the bony meatus, in the form of a triangular patch, but elsewhere they appear to be absent.

The **arteries** are derived from the posterior auricular, temporal, and internal maxillary; and the **nerves** from the auriculo-temporal and the auricular branch of the vagus.

THE MIDDLE EAR

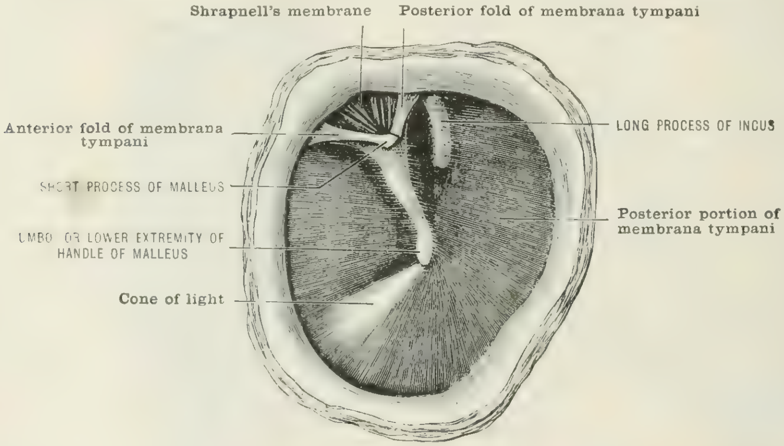
The **Membrana Tympani** is an irregularly rounded concave membrane stretched obliquely across the bottom of the osseous meatus in such wise as to form an obtuse angle with its upper wall (according to Von Tröltsch, 140°) and an acute one with its lower.

The circumference of the membrane is lodged in the groove of the tympanic ring (fig. 498A). Above and in front where the ring is wanting there is a slight recess known as the notch of Rivinus, and here the membrane is extended outwards, to unite with the grooveless margin of the tympanum to form what is known as the **Rivinian segment.**

The shape of the membrane varies with that of the inner end of the meatus. Its long axis is from above downwards and forwards. The membrane, broadly viewed, is concave externally, and convex towards the cavity of the tympanum. This is mainly due to the traction of the handle of the malleus, which descends obliquely downwards and backwards between its two inner layers to a point a little below the centre of the membrane. This curvature is deepest at the **umbo,** opposite the flattened extremity of the handle. In front of and below the umbo, extending towards the periphery, the membrane is slightly convex externally.

At the anterior superior pole, the short process of the malleus is plainly visible as a rounded point projecting outwards. A fold of the membrane passes backwards, and another forwards from this spot, and above these folds may, under favorable conditions, be seen two short, tightly stretched striæ, which, taking origin from the corners of the notch of Rivinus above, converge as they descend to meet at the short process. The membrane between these striæ and the edge of the notch is thin and flaccid, and appears above the short process as a small pit-like depression (membrana Shrapnelli). An anastomosis between the tympanic vessels and those of the external meatus occurs at this spot.

FIG. 497.—EXTERNAL VIEW OF THE LEFT MEMBRANA TYMPANI. (Enlarged from life.)


Shrapnell's membrane
Posterior fold of membrana tympani
Anterior fold of membrana tympani
LONG PROCESS OF INCUS
SHORT PROCESS OF MALLEUS
Posterior portion of membrana tympani
UMBO OR LOWER EXTREMITY OF HANDLE OF MALLEUS
Cone of light

Viewed from within, the head of the malleus is seen above the membrane articulating with the incus, its curved handle passing downwards and slightly backwards between its layers, and strongly projecting from the inner surface. The chorda tympani nerve may be seen crossing the neck of the malleus forwards to the Glaserian fissure. Folds of the membrane occur in front of and behind the malleus, bounding what are known as the anterior and posterior pouches of the membrana tympani. The free margin of the posterior pouch is commonly well marked. Passing slightly downwards and outwards to the base of the handle of the malleus, is the strongly marked fold containing the tendon of the tensor tympani muscle.

Structure.—The membrana tympani consists of **three** layers—a special **fibrous layer,** with a **cuticular covering** externally continuous with that which lines the external auditory meatus; and a **mucous lining** internally derived from the tympanic cavity.

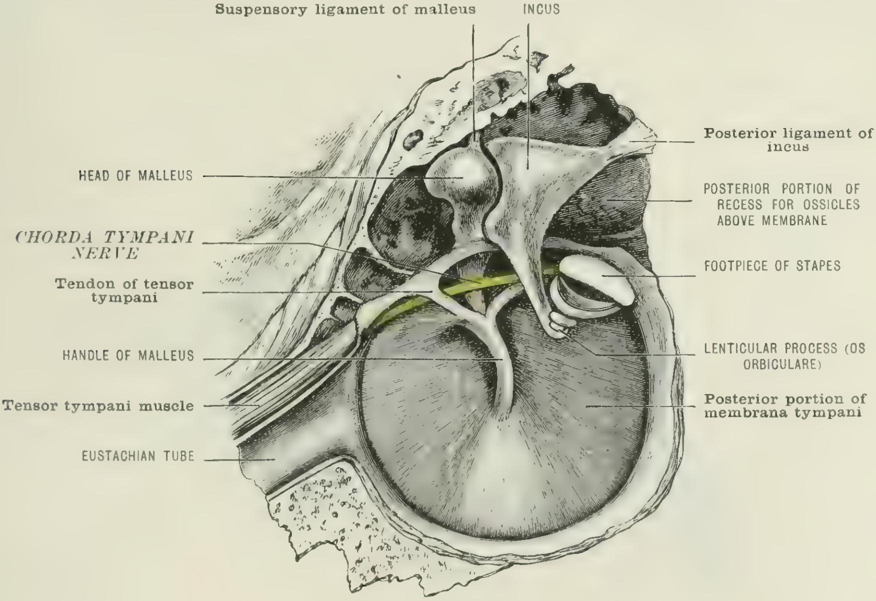
The **fibrous layer** consists of two lamellæ closely connected—an **external,** in which the fibres radiate from the handle of the malleus; and an **internal,** the fibres of which are arranged concentrically, and are especially strong at the circumference.

The membrane of Shrapnell is extremely thin, and consists only of the outer and inner layers, the fibrous layer being absent.

The handle of the malleus descends between the two inner layers, accompanied by the vessels, which are often clearly visible in the living membrane.

The **Tympanic Cavity** or middle ear is a narrow space which intervenes between the external auditory meatus and the labyrinth of the internal ear (figs. 496 and 498A). It is a narrow irregular cavity, varying in width from a twelfth to a sixth of an inch (2 to 4 mm.), and having a total height of a little more than half an inch (15 mm). It consists of two parts, a lower and narrower, bounded externally by the tympanic membrane, and an upper and wider part, called the attic, or epitympanum, which is continued backwards as the mastoid antrum into the mastoid air cells. It is prolonged downwards and forwards into the Eustachian tube, through which it communicates with the pharynx. It contains air, and it is crossed from without inwards by a movable chain of bones—the tympanic ossicles—which conduct vibrations from the membrana tympani to the internal ear.

FIG. 498.—INTERNAL VIEW OF RIGHT MEMBRANA TYMPANI. (Enlarged.)


Suspensory ligament of malleus
INCUS
Posterior ligament of incus
HEAD OF MALLEUS
POSTERIOR PORTION OF RECESS FOR OSSICLES ABOVE MEMBRANE
CHORDA TYMPANI NERVE
FOOTPIECE OF STAPES
Tendon of tensor tympani
LENTICULAR PROCESS (OS ORBICULARE)
HANDLE OF MALLEUS
Posterior portion of membrana tympani
Tensor tympani muscle
EUSTACHIAN TUBE

The **roof** is a thin plate of the petrous part of the temporal bone, which separates the cavity from the middle fossa of the skull.

The **floor** is narrower than the roof. It is formed by the tympanic plate, and it separates the cavity from the jugular fossa.

The **outer wall** is formed below by the tympanic membrane, and above by a part of the squamous portion of the temporal bone.

The *chorda tympani nerve*, which traverses the outer wall, enters by a minute orifice, the aperture of the **iter chordæ posterius**, and leaves the cavity by the **iter chordæ anterius**, which leads into the canal of Huguier. The Glaserian fissure lies immediately below the latter orifice, but these minute openings are hidden by the mucous lining.

The **inner wall** is vertical, and looks directly outwards. It presents, anteroinferiorly, a rounded prominence, the promontory, marked by grooves for the tympanic plexus, and caused by the first turn of the cochlea. In front of the promontory is the commencement of the Eustachian tube (fig. 498A), above is the outer extremity of the canal for the tensor tympani muscle bounded by a prominent ridge of bone called the cochleariform process, and behind it is a recess, the sinus tympani, which intervenes between the fenestra ovalis above and the fenestra rotunda below. The fenestra ovalis leads into the vestibule of the internal ear (fig. 498A), and in the recent state it lodges the base of the stapes. The fenestra rotunda is closed by the secondary membrane of the tympanum, which separates the scala tympani of the cochlea from the tympanic cavity. Above the fenestra ovalis there is a rounded ridge of bone, indicating the position of the aqueduct of Fallopius, which contains the facial nerve.

The **posterior wall** presents the hollow pyramid which lodges the *stapedius* muscle and the openings which lead into the mastoid cells; these vary much in size, and receive a mucous lining from the cavity.

Anteriorly the tympanic cavity is continued into the Eustachian tube, and it is separated from the carotid canal by a thin plate of bone.

The **Eustachian tube** is about one and a half inches (37 mm.) in length, passes from the tympanum downwards, forwards, and inwards. It is partly bony and partly cartilaginous.

The **osseous portion** (fig. 498A) is about half an inch (13 mm.) in length. It commences just below the orifice which transmits the tendon of the tensor tympani muscle, and, gradually contracting, ends at the isthmus by a jagged and oblique orifice between the petrous and squamous portions of the temporal bone. To it is attached the **cartilaginous portion** of the tube, which is about an inch in length (24 mm.). This is composed of an elongated triangular plate, so folded upon itself as to leave an interval below which is completed by fibrous tissue. At first the canal is narrow, but it becomes much expanded towards its trumpet-shaped termination. Its orifice, which is somewhat oval, opens into the upper part and side of the pharynx, on a level with and just behind the inferior meatus of the nose.

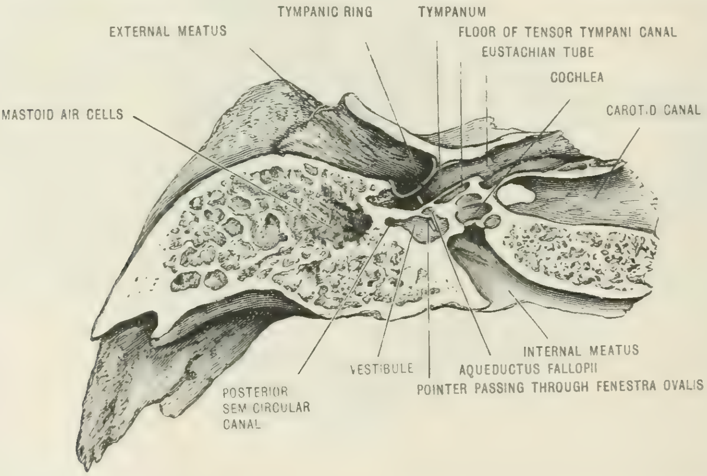


FIG. 498A.—HORIZONTAL SECTION OF LEFT TEMPORAL BONE, SHOWING THE VARIOUS PARTS OF THE EAR.

The **mucous membrane** possesses a ciliated lining. It is thin near the tympanic cavity, but it is much more vascular, thicker, and possesses mucous glands and adenoid tissue near its pharyngeal orifice.

Sections of the cartilaginous portion of the tube show that the cartilaginous plate is curled round like a hook with the bend above and the shank internal. The membranous portion is thin where it is attached to the tip of the hook, but that it becomes much thicker below. A small space near the bony portion of the tube, immediately below the hook, remains permanently open, but elsewhere the walls are in contact, except when separated by the action of the tensor palati muscle, or when forcibly driven asunder, as in the act of sneezing, etc.

A number of small sesamoid fibro-cartilages, some of which are visible to the naked eye, are buried in the submucous tissue.

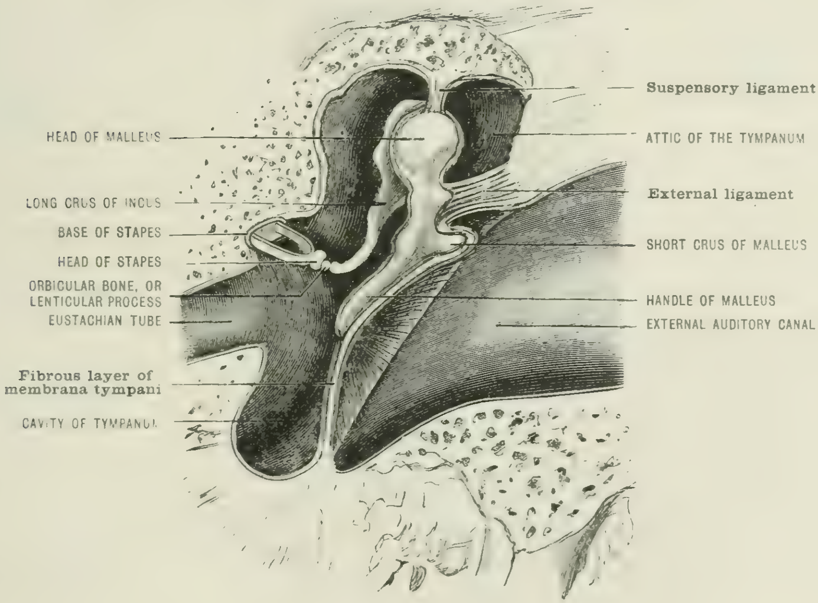
The **ossicles of the ear** are described on pages 66–68.

Articulation of the Ossicles.—The malleus with the incus. The oblong articular surface which descends as far as the neck, on the posterior surface of the head of the malleus, is divided into two portions by a nearly vertical edge. The incus presents a corresponding surface similarly divided into two portions, and both of these surfaces are coated by a delicate layer of hyaline cartilage. A thin **capsule,** from the inner surface of which a delicate wedge-shaped **meniscus** projects from above into the cavity of the joint, is attached to the grooves, which limit the articular surfaces. The mechanism has been compared by Helmholtz to the check movement inside the key of a Geneva watch, and permits considerable gliding between the two bones.

The incus with the stapes.—This joint is formed by the convex surface of the lenticular process (**orbicular bone**) which terminates the long crus of the incus and the corresponding concave surface of the head of the stapes. Both surfaces are covered with a layer of hyaline cartilage.

The **elastic capsular ligament** permits but very slight separation between the bones, but allows a somewhat freer lateral movement. This articulation has been regarded by some writers as a synchondrosis, but it is now usually described as a true joint.

FIG. 499.—SECTION OF THE TYMPANUM, ETC. (Enlarged.)


Suspensory ligament
HEAD OF MALLEUS
ATTIC OF THE TYMPANUM
LONG CRUS OF INCUS
External ligament
BASE OF STAPES
SHORT CRUS OF MALLEUS
HEAD OF STAPES
ORBICULAR BONE, OR LENTICULAR PROCESS
HANDLE OF MALLEUS
EUSTACHIAN TUBE
EXTERNAL AUDITORY CANAL
Fibrous layer of membrana tympani
CAVITY OF TYMPANUM

The stapes with the margin of the fenestra ovalis.—The so-called **annular ligament** is not equally broad throughout, and consists of elastic fibres which radiate as they pass outwards from the edge of the footpiece of the stapes to the margin of the fenestra. According to Toynbee, these edges are covered by a thin layer of cartilage.

The Ligaments of the Ossicles.—In addition to the capsular ligaments already described, certain well-marked bands limit the movements of the ossicles.

The **superior ligament of the malleus** descends as a firm rounded band from the upper and outer wall of the tympanic cavity to the head of the malleus. It limits the outward movement of the handle of the malleus.

The **anterior ligament of the malleus** is broad and strong. According to Helmholtz it encircles the long process of the malleus, and is inserted into the fore part of its neck and head.

Some of the fibres of this ligament have been described as muscular under the name of the laxator tympani muscle. But although occasionally muscular fibres can be detected, in the majority of cases they appear to be absent.

The **external ligament of the malleus** prevents the handle of the malleus being turned too much outwards. It passes from the margins of the notch of Rivinus to the short process of the malleus.

The ligament of the incus.—The short crus of the incus is covered with a layer of fibro-cartilage and rests on a depression of the posterior tympanic wall, close to the orifice leading into the mastoid cells. The posterior ligament binds the process to this wall.

The Muscles of the Tympanum.—Two muscles—the tensor tympani and the stapedius, both of which lie within bony canals—transmit their tendons into the cavity of the tympanum for insertion into the chain of ossicles.

The **tensor tympani** is a penniform muscle about half an inch in length; it **arises** in small part from the cartilaginous Eustachian tube and adjacent surface of the sphenoid bone as well as from the wall of the canal in which it lies. The tendon, which extends outwards almost at a right angle to the belly of the muscle, can be traced some distance inwards on its lower aspect. It is **inserted** on the inner margin of the handle of the malleus, near its root. The tendon glides within a sheath continuous with the periosteum lining the canal and surrounded by mucous membrane. This muscle draws the handle of the malleus, and with it the membrana tympani, inwards.

The **stapedius** is a pyriform muscle; it **arises** from the interior of the pyramidal eminence which projects from the posterior wall of the tympanum. The tendon, which can be traced inwards for more than half the length of the muscle, passes through the aperture at the summit of the eminence, to be **inserted** into the posterior aspect of the neck of the stapes. Its tendon, like that of the tensor tympani, is surrounded by a fibrous sheath enveloped in the tympanic mucous membrane. This muscle depresses the posterior, whilst at the same time it slightly raises the anterior, end of the footpiece of the stapes.

Nerves.—The stapedius is supplied by the facial nerve. The tensor tympani receives a filament from the otic ganglion which is probably derived from the motor portion of the fifth nerve.

The **Mucous Membrane of the Tympanum** is continuous through the Eustachian tube with that which lines the pharynx. It is thin and transparent, and in places it is easily detached.

Several vascular folds extend from the tympanic walls to the ossicles, all of which receive a complete covering of mucous membrane.

The folds divide parts of the cavity into pouch-like recesses, four of which, lying in relation with the malleus, are of some importance; they are the superior and inferior external pouches and the anterior and posterior pouches of Tröltsch. The superior external pouch lies in the epitympanic region, to the outer side of the heads of the malleus and incus, and above the anterior and external ligaments of the malleus, which separate it from the inferior external pouch below. The inferior external pouch lies between the last mentioned ligaments above and the short process of the malleus below. It is of special clinical importance because it is bounded externally by the flaccid portion of the membrana tympani, anteriorly it is closed but posteriorly it opens into the general cavity. The pouches of Tröltsch lie in front of and behind the handle of the malleus, and they are separated by a fold of mucous membrane which envelops the chorda tympani nerve.

The mucous membrane of the roof of the tympanum and that which lines the membrana tympani and covers the ossicles possesses a flattened non-ciliated epithelium. Elsewhere for the most part, including the Eustachian tube, it is columnar and ciliated.

Vessels and nerves of the tympanum.—Arteries.—The **tympanic branch** of the internal maxillary which passes through the Glaserian fissure, and the **stylomastoid branch** of the posterior auricular which passes through the Fallopian canal, supply the front and back part of the tympanic cavity, and form a vascular chain around the circumference of the membrana tympani. In addition to these chief branches the hiatus Fallopii transmits the **petrosal branch** from the middle meningeal, whilst fine branches leave the carotid artery as it traverses the carotid canal and pass into the tympanic cavity. The ascending pharyngeal sends branches to the Eustachian tube, some of which reach the tympanum.

Veins.—The veins empty into the superior petrosal sinus and into the temporomaxillary vein.

Nerves.—The tympanic mucous membrane is supplied by the **tympanic plexus** which occupies the grooves on the promontory and inner wall of the cavity.

The plexus is formed by the following nerves.

The **tympanic branch of the glosso-pharyngeal,** which enters the cavity through a foramen in the floor; a **communicating branch** from the **carotid plexus of the sympathetic,** which passes through the carotid canal.

A branch from the **great superficial petrosal,** which enters by the inner wall close in front of the fenestra ovalis; and one from the **small superficial petrosal,** which enters near the canal for the tensor tympani.

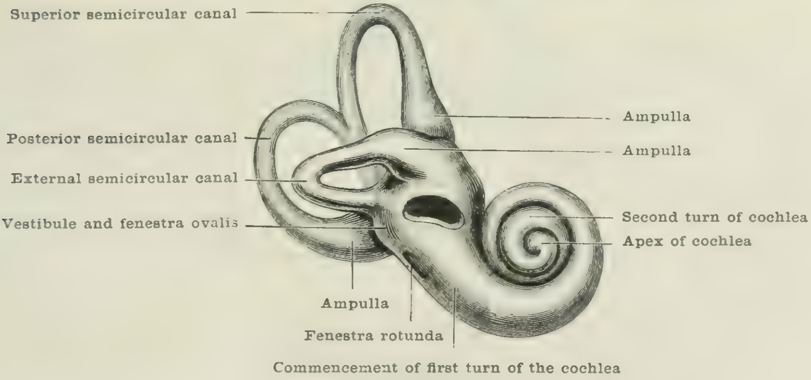
The course of the chorda tympani nerve has already been sufficiently indicated (page 762).

THE INTERNAL EAR, OR LABYRINTH

The **INTERNAL EAR,** or **LABYRINTH,** is the essential part of the organ of hearing, and receives the terminations of the auditory nerve.

The **Osseous Labyrinth** is divided into three portions: the **vestibule,** the **semicircular canals,** and the **cochlea**—recesses hollowed in the substance of the petrous portion of the temporal bone.

FIG. 500.—THE OSSEOUS LABYRINTH OF THE RIGHT SIDE.
(Modified from Soemmerring. Enlarged.)


Superior semicircular canal
Ampulla
Ampulla
Posterior semicircular canal
External semicircular canal
Vestibule and fenestra ovalis
Second turn of cochlea
Apex of cochlea
Ampulla
Fenestra rotunda
Commencement of first turn of the cochlea

The **Vestibule** lies between the cochlea and semicircular canals, on the inner side of the tympanum (fig. 489A). It is a laterally compressed ovoidal cavity, and is about one-fifth of an inch in horizontal and vertical measurement.

The **outer wall** presents the **fenestra ovalis** filled with the foot-piece of the stapes and its annular ligament. On its **inner wall** there is a small saucer-like depression, the **fovea hemispherica,** perforated below and in front by several minute orifices (macula cribrosa) for the filaments of the auditory nerve. Immediately behind this is a vertical ridge, the pyramidal eminence or crista vestibuli, behind which is the orifice of the **aqueductus vestibuli.**

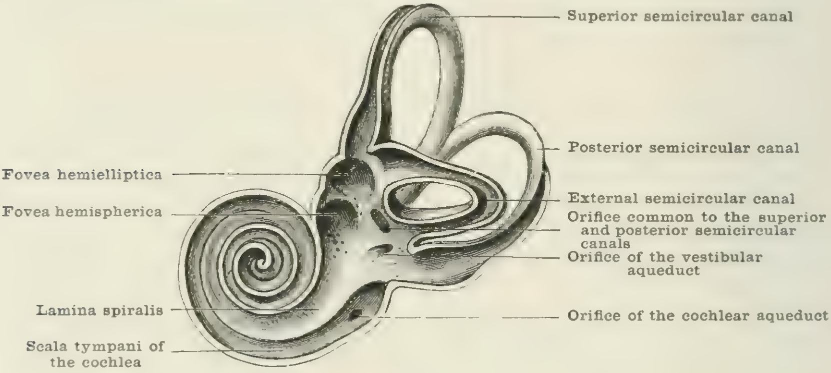
On the roof there is a second depression, oval in shape, the **fovea hemielliptica.** The two depressions are separated by the pyramidal eminence.

Behind, the semicircular canals open by five orifices; and **in front** by means of a large oval opening, **apertura scalæ vestibuli,** the vestibular cavity communicates with the **scala vestibuli of the cochlea.**

The **Three Semicircular Canals** are placed above and behind the vestibule. They are unequal in length, but each forms the greater part of a circle, is laterally compressed, and measures about one-twentieth of an inch (1·5 mm.) in diameter. One extremity of each canal is suddenly dilated to nearly double its size to form the **ampulla.** As two of the canals join to open by a common orifice, collectively they present only five openings.

The **superior semicircular canal,** the highest of the canals, is almost vertical, and is directed transversely. A smooth eminence on the anterior surface of the petrous bone closely corresponds to the summit of its arch. Its ampullary end is at the outer extremity, and presents a separate opening at the upper part of the vestibule; the opposite end, which is not dilated, joins to form a common orifice with the similar extremity of the posterior canal.

FIG. 501.—INTERIOR OF THE OSSEOUS LABYRINTH OF THE LEFT SIDE. (Modified from Soemmerring. Enlarged.)

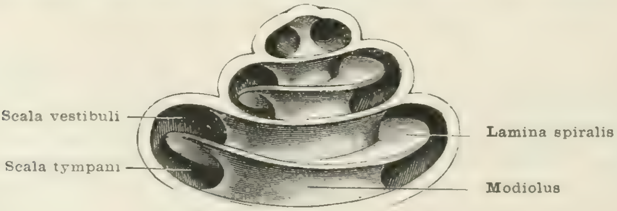

Superior semicircular canal
Posterior semicircular canal
Fovea hemielliptica
Fovea hemispherica
External semicircular canal
Orifice common to the superior and posterior semicircular canals
Orifice of the vestibular aqueduct
Lamina spiralis
Orifice of the cochlear aqueduct
Scala tympani of the cochlea

The **posterior semicircular canal** is the longest. Its dilated end is placed at the lower and back part of the vestibule; its non-dilated extremity joins the superior canal. It is placed nearly vertically, and is directed backwards.

The **external semicircular canal** curves horizontally outwards, and presents two openings, of which the anterior is ampullated, in the upper and back part of the vestibular cavity.

The **Cochlea** has a rough resemblance to a snail's shell, and coils itself almost horizontally immediately in front of the vestibule. Its **base** corresponds to the lower and front part of the fundus of the internal auditory meatus (fig. 498A), and is there marked by the series of minute holes which form the **tractus spiralis foraminulentus,** whilst its apex is directed forwards and outwards, towards the upper and fore part of the inner wall of the tympanum.

FIG. 502.—INTERIOR OF THE OSSEOUS COCHLEA. (Enlarged.)


Scala vestibuli
Scala tympani
Lamina spiralis
Modiolus

The cochlea is about a quarter of an inch (6 mm.) in length, and its basal measurement is nearly the same. It is composed of a central pillar, the **modiolus,** or **columella,** around which curls for two and a half turns a **spiral canal,** which contains a delicate spiral shelf or plate, the **lamina spiralis.** This partially divides its cavity into two portions, as it follows its windings from base to apex. Near the apex it ends in a hook-like process, the **hamulus,** which bounds a small opening, the **helicotrema.** The osseous spiral canal is nearly an inch and a half (about 3·5 cm.) in length. The **lamina spiralis** is thin and dense in structure at its edge, but it is spongy and channelled with canals for nerves and blood-vessels where it starts shelf-like from the modiolus.

The spiral canal of the modiolus coils round the pillar as it tunnels the base of the spiral lamina.

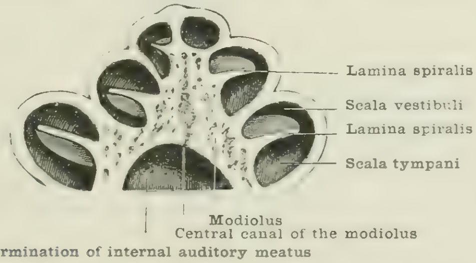
In the recent state, membranous structures complete the bony partition into two separate chambers, or scalæ: the **scala vestibuli** and the **scala tympani,** which communicate through the helicotrema at the summit of the cochlea.

The **scala vestibuli** commences from the cavity of the vestibule; in its **first** turn it is somewhat narrower than the scala tympani.

The **scala tympani** commences at the fenestra rotunda, which is filled with the secondary membrane of Scarpa, and forms a kind of window which shuts it off from the cavity of the tympanum. Near its commencement is the small orifice of the aqueductus cochleæ, which lodges a minute vein, and forms a communication with the subarachnoid space.

The **central axis,** or **modiolus,** extends from the base to the apex of the cochlea. It starts with a broad base where it corresponds with the first turn of the cochlea, and it is pierced by minute canals to receive the filaments of the cochlear division of the auditory nerve. In the second coil the axis is diminished by more than half, and it terminates in the remaining half coil or **cupula** in a bony plate, the **infundibulum,** which expands towards the summit of the cochlea, with which it becomes continuous. The **central canal of the modiolus** runs through its centre.

FIG. 503.—SECTION OF THE OSSEOUS COCHLEA. (Enlarged.)


Lamina spiralis
Scala vestibuli
Lamina spiralis
Scala tympani
Modiolus
Central canal of the modiolus
Termination of internal auditory meatus

The **Membranous Labyrinth,** which lies within the bony labyrinth just described, receives the terminations of the auditory nerve. It is for the most part separated by the **perilymph** from the membrane which lines the bony chambers, and it contains within its own cavity the fluid endolymph. In the vestibule and semicircular canals it bears a near resemblance (though it is much smaller) to the enclosing structures, but in the cochlea it not only divides the bony canal into the two scalæ, but forms between them a third space, the **canal of the cochlea.**

Within the vestibule the membranous labyrinth consists of two sacs, which do not directly communicate: the **utricle,** connected with the semicircular canals: and the **saccule,** with the cochlea.

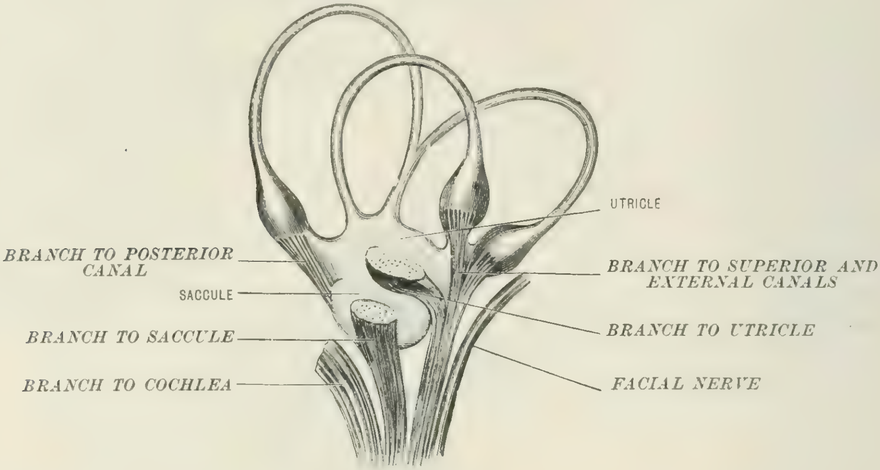
The **Utricle** is the larger. It is oblong, laterally compressed; it occupies the upper and back part of the cavity, and is in contact with the wall of the fovea hemielliptica. Filaments of the auditory nerve are distributed to the wall of the sac opposite the crista vestibuli, passing through the bony foramina already described. Its wall is here thicker than elsewhere, and calcareous particles (otoliths) are attached to its inner surface. Behind, the cavity communicates by five orifices with the semicircular canals.

The **Saccule,** which is slightly flattened, occupies the front and lower part of the cavity at the opening of the scala vestibuli of the cochlea. From the hollow of the fovea hemispherica it receives numerous nerve filaments, and presents a thickened area with attached otoliths.

The membranous canal of the cochlea is connected with the saccule by a short canal, **canalis reuniens.**

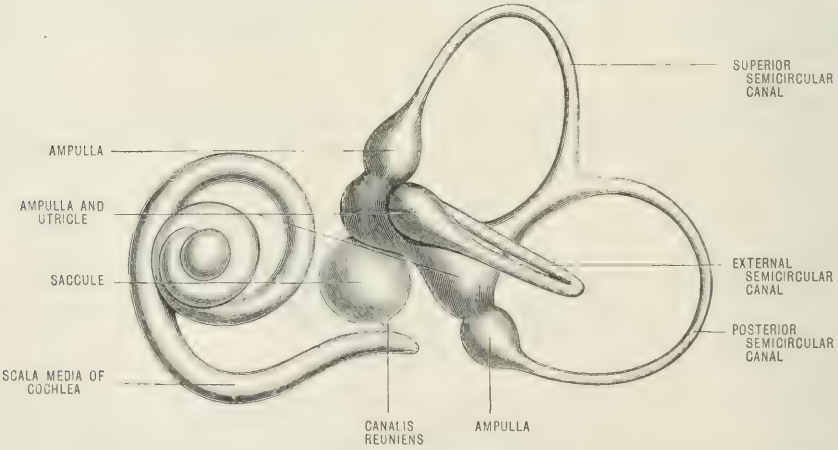
The two sacs are indirectly connected by means of a small tube, ductus endolymphaticus, which leaves the saccule, joins the commencement of a minute canal which passes to the utricle, and descends in the aqueductus vestibuli to terminate in an enlargement, the saccus endolymphaticus.

FIG. 504.—MEMBRANOUS LABYRINTH (MAGNIFIED), WITH NERVES. (Modified from Breschet.)


UTRICLE
BRANCH TO POSTERIOR CANAL
SACCULE
BRANCH TO SUPERIOR AND EXTERNAL CANALS
BRANCH TO SACCULE
BRANCH TO UTRICLE
BRANCH TO COCHLEA
FACIAL NERVE

Within each semicircular canal the membranous labyrinth occupies less than a third of the area of the tube, but follows its curves and repeats its ampullary enlargement; and here the wall of the membranous canal is thicker and more opaque, and more completely fills the cavity. The membranous ampullæ are flattened on their external walls, where they receive vascular and nervous filaments, and their cavities are partially divided by a transverse crest or ridge (crista acustica). The outer convex border of each membranous canal is fixed to the osseous wall.

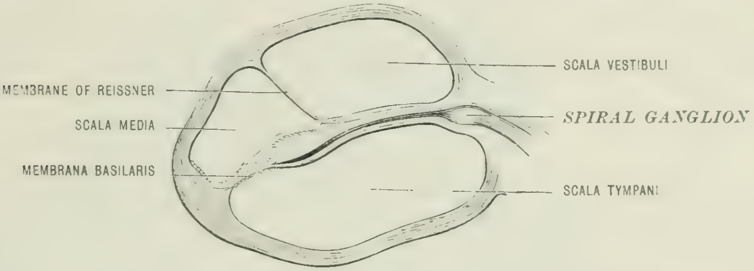
FIG. 505.—ENLARGED DIAGRAMMATIC VIEW OF MEMBRANOUS LABYRINTH.


SUPERIOR SEMICIRCULAR CANAL
AMPULLA
AMPULLA AND UTRICLE
SACCULE
EXTERNAL SEMICIRCULAR CANAL
POSTERIOR SEMICIRCULAR CANAL
SCALA MEDIA OF COCHLEA
CANALIS REUNIENS
AMPULLA

Structure.—The membranous labyrinth consists of three layers: a **tunica propria,** with a **fibrous investment** externally, and an **epithelial lining** within.

Within the cochlea, the membranous structures divide the canal into three compartments. The lamina spiralis (which in macerated specimens only partially divides it) is continued into a projection from the periosteum of the outer wall (spiral ligament) by means of a distinct membrane, **membrana basilaris**, thus completely roofing in the scala tympani which before communicated with the scala vestibuli. In addition, a delicate membrane, the **membrane of Reissner**, stretches from the upper surface of the lamina internal to its free edge to the periosteum of the outer wall, shutting off a small triangular space (scala media) from the scala vestibuli; the sides of this space are bounded by the two membranes (basilar and Reissner), and its base which lies externally is formed by the osseous wall with its periosteal lining. This canal is lined with epithelium, winds through the whole length of the cochlea, and is commonly known as the **ductus cochlearis**, or **membranous canal of the cochlea.** It ends blindly by pointed extremities, one situated at the apex of the cochlea and the other at its base, the latter lies in relation with the floor of the vestibule and receives the small canal already described, the **canalis reuniens,** which proceeds from the saccule. The canal of the cochlea and the saccule are thus brought into communication.

Fig. 506.—Enlarged View of Longitudinal Section of the First Turn of the Cochlea, showing the Positions and Boundaries of the Three Scalæ.



The **Auditory Nerve** divides into two portions before it reaches the fundus of the internal auditory meatus.

The **superior division** consists of three branches which pass to the crista vestibuli, through special openings, to be distributed to the **utricle** and the ampullary enlargements of the **superior** and **external semicircular canals.**

The **inferior division** supplies the **cochlea** through the foramina of the tractus foraminulentus; also a branch to the **saccule,** the filaments of which pass through the openings of the fovea hemispherica; and a longer branch to the **posterior semicircular canal,** which reaches it by a special channel, the foramen singulare, situated behind the foramina which transmit the filaments to the saccule.

Vessels.—The **internal auditory branch** of the basilar artery, which accompanies the auditory nerve, supplies both the **vestibule** and **cochlea,** with their **membranous contents.** The **veins** correspond and open into the inferior petrosal sinus, which also receives the minute veins which traverse the aqueductus vestibuli.

THE TONGUE

By ARTHUR HENSMAN, F.R.C.S.

Revised for Second Edition by ARTHUR ROBINSON, M.D., M.R.C.S.

LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

The **tongue** is a freely movable, highly sensitive, and muscular organ, and is endowed with the **special sense of taste.** It participates, moreover, in the **function of speech,** and plays an important part in **mastication** and **deglutition.**

Its upper surface, or **dorsum,** with its sides and **tip,** are free, whilst its base is attached by muscles to the hyoid bone and lower jaw. Folds of mucous membrane loosely connect it with the epiglottis and soft palate, as well as with the symphysis of the lower jaw. From beneath its rounded borders the mucous covering becomes continuous with the inner surface of the gums. The anterior two-thirds of the tongue occupies the floor of the mouth, lying between the halves of the lower jaw, with its convex dorsum overarched by the vault of the palate, and its sides and tip in contact with the teeth and gums. The posterior third of the dorsum, situated in the anterior wall of the pharynx, forms a rounded surface overhanging the epiglottis.

The **mucous membrane,** which is really a modified skin, covers the whole of the free surface of the tongue. It forms three folds: the **glosso-epiglottidean** in connection with the epiglottis; and on each side of the median fold—**frænum epiglottidis**—is formed the **glosso-epiglottidean pouch,** or **vallecula,** which is bounded externally by the more rounded lateral fold. On each side of the tongue, near the junction of the posterior and middle third, the membrane ascends to form the **anterior pillars of the fauces,** and in front beneath the tip it forms the sharp fold of the **frænum linguæ** (fig. 509), which extends forwards to the back of the symphysis.

A slight longitudinal groove, the **median raphe,** divides the dorsum of the tongue along its anterior two-thirds. It ends posteriorly near a small foramen, the **foramen cæcum,** which represents the upper termination of the thyro-glossal duct. The orifice, however, is not at all constant in the adult tongue, although occasionally it is present and may sometimes lead into the still patent duct which tunnels the tongue as far as the body of the hyoid bone. The course of the obliterated duct may in many cases be demonstrated.

The foramen cæcum is easily seen in the fœtus at the angle of meeting of two shallow grooves which form the V-shaped line behind the circumvallate papillæ. These grooves indicate the line of junction of the anterior and posterior portions of the tongue, and are faintly visible in the adult organ.

The papillæ crowd the anterior two-thirds of the dorsum as well as the sides and tip of the tongue, but at the back they are small and hidden by the epithelial coating. Of the papillæ three chief kinds can be distinguished.

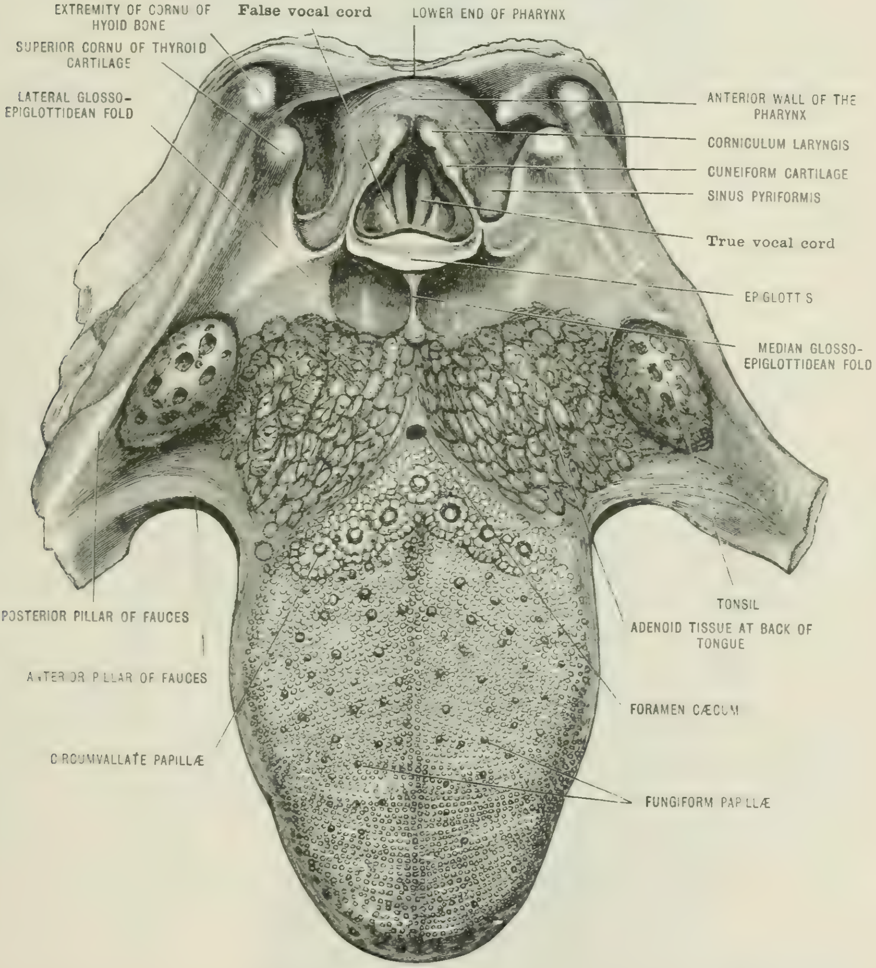
The **circumvallate** or **calyciform papillæ** are the largest, but they are few in number, varying from seven or eight to twelve, and they form a V-shaped line in front of and parallel with the grooves already mentioned.

Each papilla presents a narrow attached base and a broad free end, and is seated in a circular cup which is surrounded by a rim or vallum.

Upon the bases of most of these papillæ a central depression marks the orifice of one or more glands. Secondary papillæ lie hidden under the thick epithelial covering both of the chief papilla and the circular rim which surrounds it.

The **fungiform papillæ** are more thinly covered with epithelium, and are redder in colour than the smaller papillæ amongst which they are scattered. They occur irregularly over the dorsum, sides, and tip of the tongue, and are most numerous in the two latter situations; each papilla is attached by a comparatively narrow base and has a broader, rounded, and free extremity, studded with smaller secondary papillæ.

FIG. 507.—DORSUM OF THE TONGUE.


EXTREMITY OF CORNU OF HYOID BONE
False vocal cord
LOWER END OF PHARYNX
SUPERIOR CORNU OF THYROID CARTILAGE
LATERAL GLOSSO-EPIGLOTTIDEAN FOLD
ANTERIOR WALL OF THE PHARYNX
CORNICULUM LARYNGIS
CUNEIFORM CARTILAGE
SINUS PYRIFORMIS
True vocal cord
EPIGLOTTIS
MEDIAN GLOSSO-EPIGLOTTIDEAN FOLD
TONSIL
ADENOID TISSUE AT BACK OF TONGUE
POSTERIOR PILLAR OF FAUCES
ANTERIOR PILLAR OF FAUCES
FORAMEN CÆCUM
CIRCUMVALLATE PAPILLÆ
FUNGIFORM PAPILLÆ

The **filiform** or **conical papillæ,** named from their general shape, thickly beset the whole of the dorsum, sides, and tip of the tongue in front of the circumvallate group. They faintly ridge the organ with delicate lines, which posteriorly lie parallel with the circumvallate papillæ, but become more and more transverse in direction as they approach the tip and sides of the tongue. They present secondary papillæ upon their surfaces thickly overlaid with epithelium.

The **lingual glands** are especially abundant near the **foramen cæcum** and in the neighborhood of the circumvallate papillæ, as well as along the borders of the tongue.

A special group forms an elongated mass, the **gland of Nuhn,** on either side of the organ, and just beneath its tip. It occupies the groove between the genio-hyo-glossus muscle and the inferior lingualis.

Fig. 508.—The Fœtal Tongue.

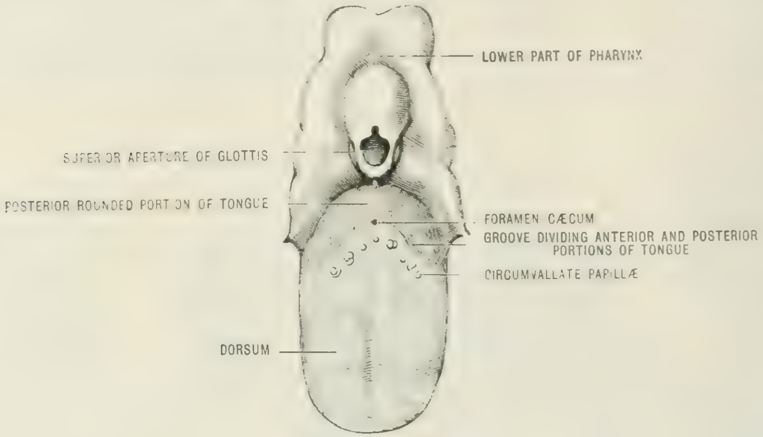
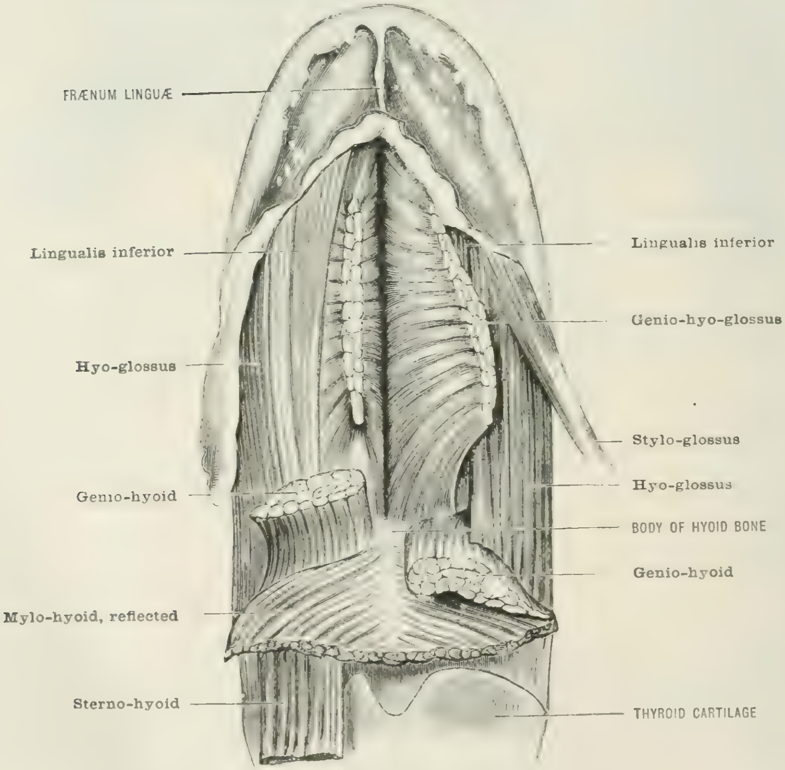

LOWER PART OF PHARYNX
SUPERIOR APERTURE OF GLOTTIS
POSTERIOR ROUNDED PORTION OF TONGUE
FORAMEN CÆCUM
GROOVE DIVIDING ANTERIOR AND POSTERIOR PORTIONS OF TONGUE
CIRCUMVALLATE PAPILLÆ
DORSUM

Fig. 509.—Under Surface of the Tongue with Muscles.


FRÆNUM LINGUÆ
Lingualis inferior
Lingualis inferior
Genio-hyo-glossus
Hyo-glossus
Stylo-glossus
Hyo-glossus
Genio-hyoid
BODY OF HYOID BONE
Genio-hyoid
Mylo-hyoid, reflected
Sterno-hyoid
THYROID CARTILAGE

The mucous membrane of the posterior third of the tongue contains abundant **lymphoid tissue,** collected into rounded masses. This often becomes much developed, and gives to this part of the tongue an irregular nodular appearance.

FIG. 510.—TRANSVERSE SECTION THROUGH THE LEFT HALF OF THE TONGUE. (Magnified.)

(From a preparation by Mr. J. Pollard, Middlesex Hospital Museum.)

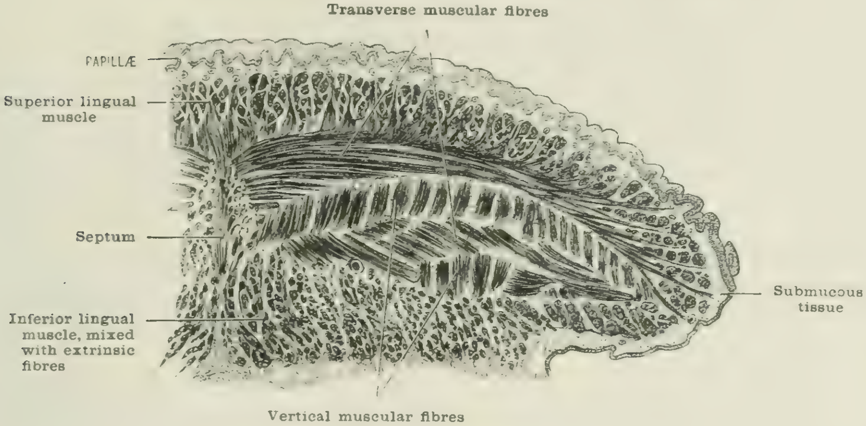
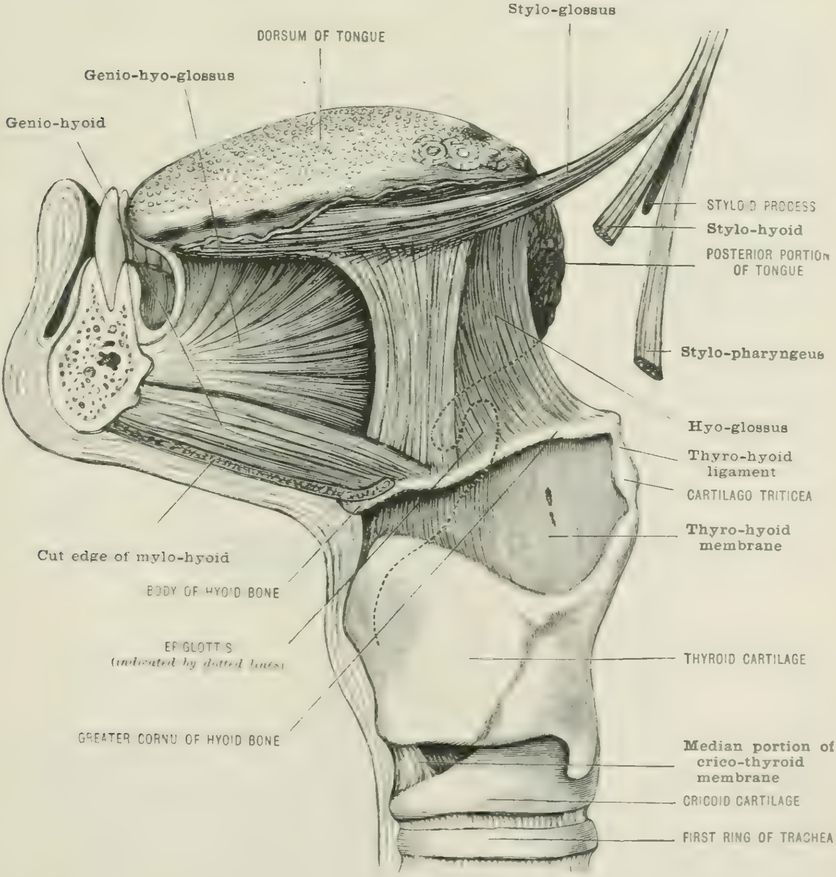

Transverse muscular fibres
PAPILLÆ
Superior lingual muscle
Septum
Inferior lingual muscle, mixed with extrinsic fibres
Submucous tissue
Vertical muscular fibres

FIG. 511.—SIDE VIEW OF THE TONGUE, WITH ITS MUSCLES.


Stylo-glossus
DORSUM OF TONGUE
Genio-hyo-glossus
Genio-hyoid
STYLOID PROCESS
Stylo-hyoid
POSTERIOR PORTION OF TONGUE
Stylo-pharyngeus
Hyo-glossus
Thyro-hyoid ligament
CARTILAGO TRITICEA
Thyro-hyoid membrane
Cut edge of mylo-hyoid
BODY OF HYOID BONE
EPIGLOTTIS (indicated by dotted lines)
THYROID CARTILAGE
GREATER CORNU OF HYOID BONE
Median portion of crico-thyroid membrane
CRICOID CARTILAGE
FIRST RING OF TRACHEA

A **fibrous septum** separates the halves of the tongue and extends in the middle plane from base to apex; and a strong fibrous membrane, the **hypoglossal membrane,** passes from beneath the base of the tongue to the body of the hyoid bone.

The Muscles of the Tongue.—The muscles of the tongue are both **extrinsic,** and **special** or **intrinsic.**

The **extrinsic muscles** are the hyo-glossus, genio-hyo-glossus, stylo-glossus, palato-glossus, and a small part of the superior constrictor. (For extrinsic muscles of tongue see pages 451–454.)

The intrinsic muscles.—The **lingualis superior** constitutes a superficial longitudinal stratum, which extends from the base to the tip of the organ, immediately beneath the mucous membrane. The fibres form short fascicles attached to the overlying tissues, and are placed between the hyo- and stylo-glossi muscles of the opposite sides of the tongue, both pairs of which, near the base, overlap the fibres of the lingualis.

The **inferior lingualis** is composed of two bands which reach from the base to the apex on the under surface of the tongue. Posteriorly some of the fibres become attached to the body of the hyoid bone. Each of these bands is placed between the hyo- and genio-hyo-glossus, and near the tip some of its fibres mix with those of the stylo-glossus muscle.

The **transverse fibres** mixed with fat lie between the two muscles just described, and form a considerable part of the bulk of the tongue. They take origin from the median fibrous septum, and, curving outwards and upwards, are inserted into the sides and dorsum of the organ.

The **vertical fibres** decussate with the transverse, and pass from the dorsum to the under surface of the tongue in curves with their concavities looking outwards. The fibres become shorter as they approach the margin of the tongue.

Arteries.—The arteries are derived from the lingual, facial, and ascending pharyngeal.

Nerves.—The nerves are—the lingual branch of the **mandibular division of the fifth,** which supplies the papillæ of the fore part and sides of the tongue; the lingual branch of the **glosso-pharyngeal,** which supplies the base and sides, including the circumvallate papillæ; the fine branches from the **superior laryngeal,** which reach the root close to the epiglottis, and a lingual branch from the facial (Testut).

The **hypoglossal** supplies the muscular substance of the tongue, as well as most of the extrinsio muscles; and the **chorda tympani** through the facial contributes also some filaments.

THE NOSE

By ARTHUR HENSMAN, F.R.C.S.

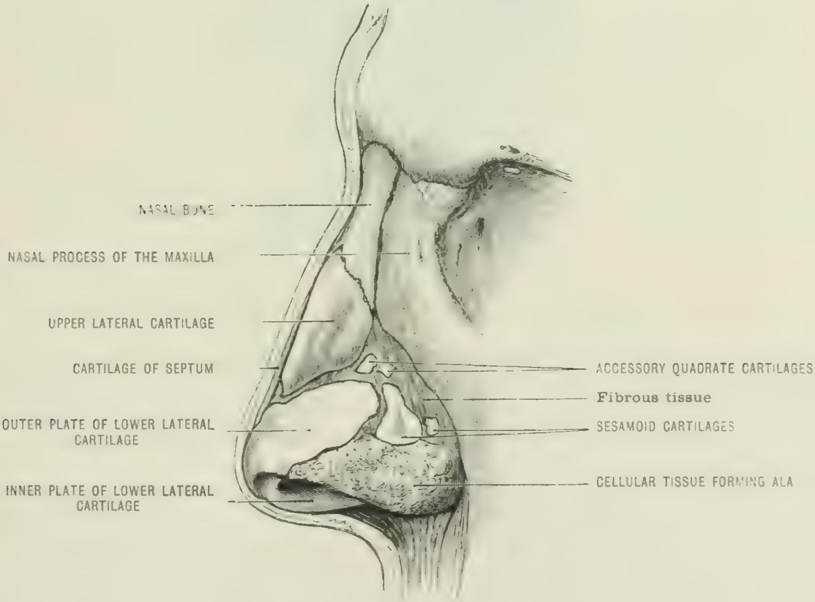
Revised for Second Edition by ARTHUR ROBINSON, M.D., M.R.C.S.

LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

The nose includes a visible external portion, the **nose proper**; and an internal cavity, the **nasal fossa**.

The **Nose Proper** is triangular in shape; its **root** above is at the forehead, from which the **bridge** or **dorsum** slopes downwards and forwards to end in a rounded **tip** or **lobe.** The **base** below overhangs the upper lip: it here presents two orifices, the **nostrils,** which are divided by the **columna.**

Fig. 512.—Side View of the Nose, showing its Cartilages, etc.


NASAL BONE
NASAL PROCESS OF THE MAXILLA
UPPER LATERAL CARTILAGE
CARTILAGE OF SEPTUM
OUTER PLATE OF LOWER LATERAL CARTILAGE
INNER PLATE OF LOWER LATERAL CARTILAGE
ACCESSORY QUADRATE CARTILAGES
Fibrous tissue
SESAMOID CARTILAGES
CELLULAR TISSUE FORMING ALA

The nostrils are protected by stiff hairs, and each opens into a cavity, extending a little above the cartilages, called the **vestibule.** Its sides slope from the dorsum outwards and backwards, and terminate below in the **alæ** or **wings,** which bound the nostrils externally. It presents a dense unyielding **bony framework,** formed by the two nasal bones, with the nasal processes of the maxillæ above, and by the projecting anterior nasal spine below. To this is added a yielding **cartilaginous portion,** which completes the organ, and forms its chief part.

The nose is enveloped in skin, lined by a mucous membrane, and supplied with vessels and nerves, and its cartilages are acted upon by small muscles.

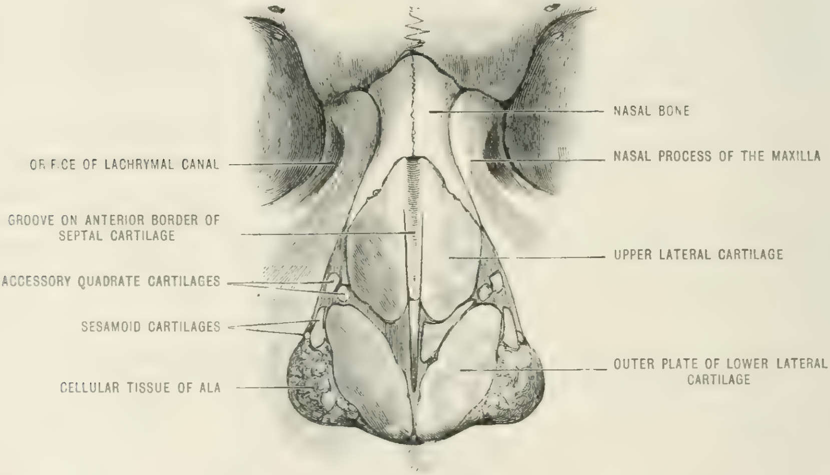
The cartilages.—The principal cartilages are five in number: a pair above, the **superior lateral**; a pair below, the **inferior lateral**; and the **cartilage of the septum,** the persistent unossified remnant of the **facial segment of the chondrocranium** (page 90). With these must be included a group of small irregular cartilages known as **sesamoid** and **accessory quadrate.**

The cartilages, ensheathed in perichondrium, are for the most part loosely held together by tough intervening fibrous tissue, and this in turn becomes continuous with the periosteum of the surrounding bones.

The **upper lateral cartilages** are nearly flat and somewhat triangular in shape, each presenting an outer and an inner surface.

Their anterior margins are continuous above with the rounded borders of a shallow groove which furrows the cartilage of the septum; but below for about two-thirds of their extent, though their edges are closely applied to the borders of the groove, there is on each side a narrow cleft of separation which opens out below into an angular notch.

FIG. 513.—ANTERIOR VIEW OF THE NOSE, SHOWING ITS CARTILAGES, ETC.


NASAL BONE
ORIFICE OF LACHRYMAL CANAL
NASAL PROCESS OF THE MAXILLA
GROOVE ON ANTERIOR BORDER OF SEPTAL CARTILAGE
UPPER LATERAL CARTILAGE
ACCESSORY QUADRATE CARTILAGES
SESAMOID CARTILAGES
OUTER PLATE OF LOWER LATERAL CARTILAGE
CELLULAR TISSUE OF ALA

Their curved posterior margins are firmly attached superficially by somewhat jagged edges to the nasal bones; but deeply, and especially near the septum, they underlie these bones for a considerable distance.

The rest of the border is smooth, free, and loosely connected by intervening fibrous tissue to the nasal process of the maxilla.

Their inferior borders are connected with the lower lateral cartilages; one or more narrow plates of cartilage occasionally intervene and fill the fibrous interval. On account of their continuity with the septal cartilage, the upper lateral cartilages should be regarded as its wings or lateral expansions. (Henle.)

The **lower lateral cartilages** are thin, pliant, and curved, and so folded backwards that each forms an inner and an outer plate.

The **inner plates** are loosely attached to one another, where they meet below the septum to form the tip of the nose and fore part of the columna.

The **outer plates** are oval, and curve backwards above the masses of dense cellular tissue which form the alæ. They maintain the contour of the nostrils, and serve to keep these orifices open. Posteriorly they are connected by fibrous tissue to the nasal margins of the superior maxillary bones.

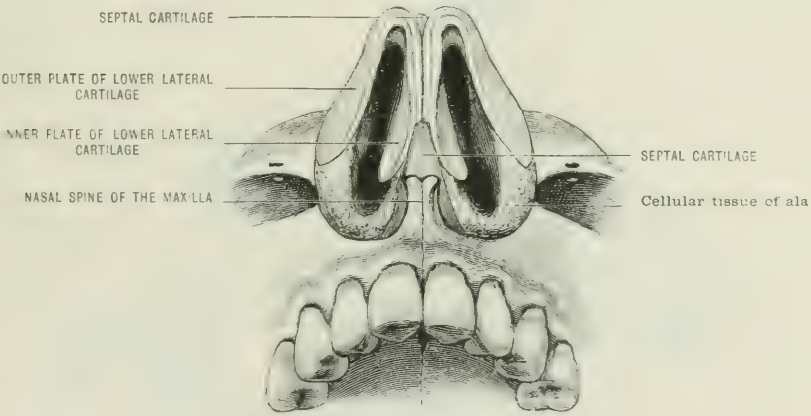
In this tissue are embedded several extremely thin and irregular cartilages named **sesamoid,** and above these commonly a pair still smaller, called **accessory quadrate.**

The **septal cartilage** fills in the triangular interval of the bony septum. The **anterior border** is attached to the nasal bones at their junction below the crest. Beyond it presents a shallow groove, the borders of which are at first continuous with the upper lateral cartilages, as already described. This groove becomes narrowed by the gradual approximation of its borders, which ultimately meet in a faint transverse ridge below. Still lower, it dips for a short distance between the inner plates of the lower lateral cartilages, which meet beyond it to form the tip of the nose.

The **posterior border** is connected with the perpendicular plate of the ethmoid, whilst its **inferior** is attached to the vomer, which is often channelled like the ethmoid plate to receive it. The anterior part of the lower border is attached to the anterior nasal spine.

The cartilage does not simply dip into the groove which is more or less marked on the upper surface of the nasal spine, but broadens out to obtain the widest possible, though somewhat lax, attachment to it. Viewed from below, it appears to embrace the spine. The border of its rounded angle in front is somewhat thickened before terminating in a thin smooth edge. It is extremely thin near the centre.

FIG. 514.—UNDER VIEW OF THE NOSE, SHOWING ITS CARTILAGES, ETC.


SEPTAL CARTILAGE
OUTER PLATE OF LOWER LATERAL CARTILAGE
INNER PLATE OF LOWER LATERAL CARTILAGE
NASAL SPINE OF THE MAXILLA
SEPTAL CARTILAGE
Cellular tissue of ala

The shape of the septal cartilage varies in relation to the extent of ossification in the bony septum, and even in the adult a strip of cartilage may extend for a varying distance backwards and upwards between the vomer and ethmoid, sometimes even reaching the body of the sphenoid bone.

It may be here noted that the septum of the nose is almost always straight in children and in aboriginal skulls (eighty per cent.); but in Europeans it is deflected to one or other side in the proportion of three out of every four.

Jacobsonian cartilages.—In the septal cartilage above the opening of Stenson's canal there is a small pouch which presents a minute opening below. This is the representative of the so-called Jacobsonian organ. A strip of cartilage underneath this, firmly adherent, but distinct from the septal cartilage, is known as the Jacobsonian cartilage.

Muscles.—The muscles are seven in number, and may be grouped as **dilators** and **constrictors.** The latter are comparatively feeble in their action.

The dilators.—The **pyramidalis nasi** is a downward prolongation of the occipito-frontalis. Each muscle descends on the side of the nose, to blend, after becoming tendinous, with the compressor nasi. They diverge from one another as they pass downwards. The **levator labii superioris alæque nasi** arises from the nasal process of the maxilla.

It divides in its passage downwards, one slip being inserted into the cartilage of the wing, the other extending to the upper lip to blend with its muscular fibres.

The two foregoing muscles may be regarded as extraordinary or reserve muscles of dilatation.

The **dilator naris** consists of two small muscular slips, requiring a lens for their proper demonstration; in some cases they are absent.

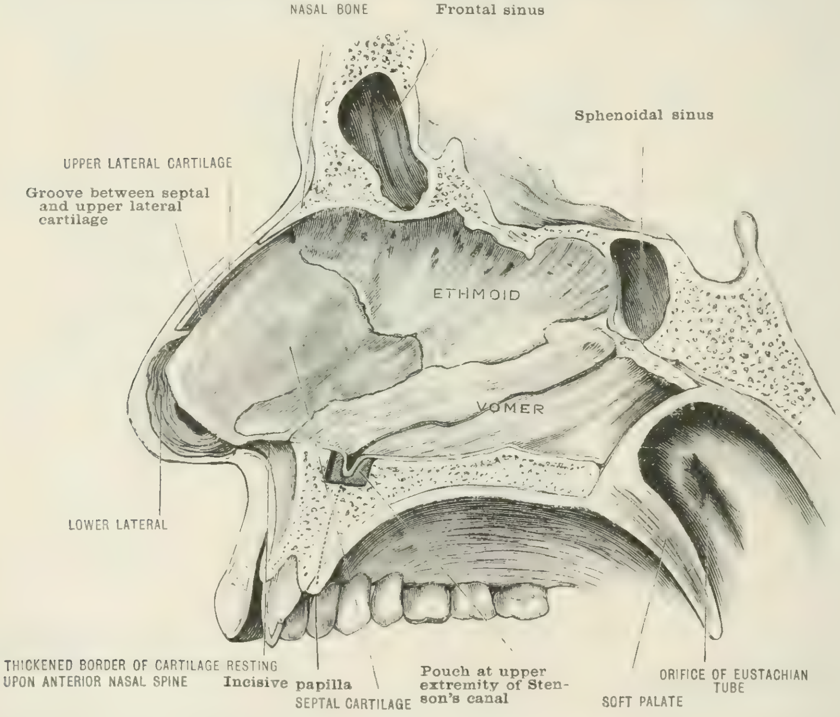
The **dilator naris anterior** is a small and indistinct muscle. It is placed between the skin and cartilage of the ala.

The **dilator naris posterior** arises from the edge of the nasal notch of the maxilla and the sesamoid cartilages, to be inserted into the margin of the nostril. In paralysis of the facial nerve, a deep inspiration through the nostril produces complete collapse of its cartilaginous wall, thus showing the importance of the dilator muscles in keeping patent the nasal orifices.

The constrictors, or compressors.—The **compressor naris** arises from the maxilla near the incisive fossa, its fibres mixing with those of the levator anguli oris. It expands as it passes inwards, to end in a thin aponeurosis, which joins with its fellow as well as with the pyramidalis, and it also blends with the subcutaneous tissue over the bridge of the nose.

Fig. 515.—Section showing Bony and Cartilaginous Septum.

The dotted lines indicate the course of the anterior palatine canal.


NASAL BONE
Frontal sinus
Sphenoidal sinus
UPPER LATERAL CARTILAGE
Groove between septal and upper lateral cartilage
ETHMOID
VOMER
LOWER LATERAL
THICKENED BORDER OF CARTILAGE RESTING UPON ANTERIOR NASAL SPINE
Incisive papilla
SEPTAL CARTILAGE
Pouch at upper extremity of Stenson's canal
SOFT PALATE
ORIFICE OF EUSTACHIAN TUBE

The **depressor alæ nasi** arises from the incisor fossa; its fibres pass upwards to the septum and posterior part of the wing.

The **compressor narium minor** consists of a few indistinct fibres, occasionally found between the alar cartilage and skin over the tip of the nose.

These muscles are all supplied by the facial nerve.

The **skin** covering the nose is for the most part thin and freely movable upon the subjacent parts, but at the tip and over the cartilages it is much thicker and more adherent and furnished with numerous sebaceous glands.

The **mucous membrane** becomes continuous with the skin at the nasal orifices, and posteriorly with the membrane which lines the nasal fossæ.

The vessels.—The **arteries** of the nose which arise from the facial are the lateralis nasi and the artery to the septum derived from the coronary of the same trunk. This latter also supplies the ala. The nasal branch of the ophthalmic and infraorbital are distributed to the sides and dorsum.

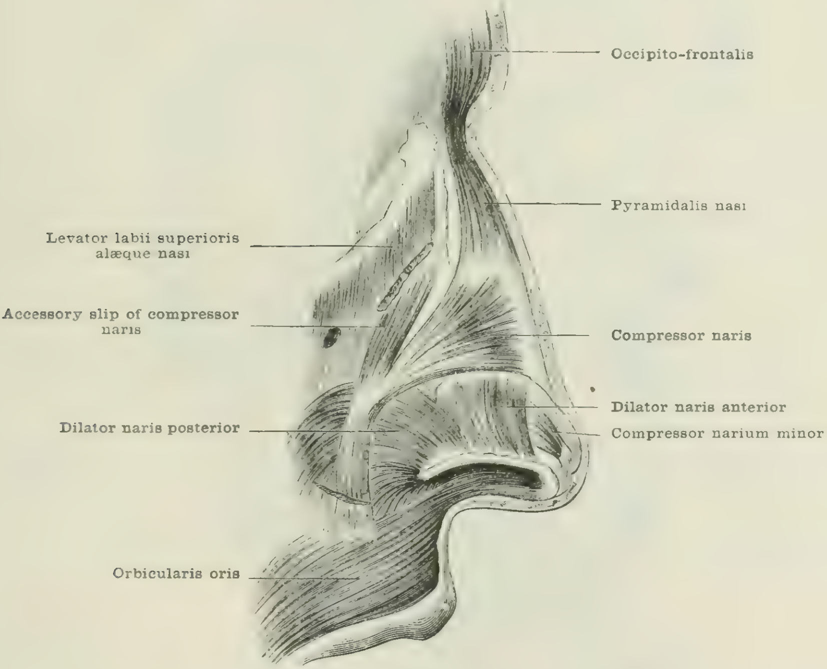
The **veins** terminate by joining the facial and ophthalmic.

The nerves.—The **nerves** are supplied by the facial, which is motory, and by the infratrochlear and nasal branch of the ophthalmic division of the fifth and the infraorbital nerve, which are sensory.

The nasal fossæ.—The nasal fossæ have been already described (page 79).

The mucous membrane (*pituitary* or *Schneiderian*).—In the recent state the area of the fossæ is much contracted by its mucous lining. This is loosely folded around the lower edges of the turbinal bones, and extends beyond them in front and behind. Especially is this marked where it envelops the inferior turbinal bone, and it is here very thick and spongy. It is, moreover, thick where it covers the septum, but thin at the bottom of the meatuses and within the sinuses. Some of the openings into the nasal cavities which are apparent in the dried skull are quite hidden in the recent state; those, however, which lead into the air-spaces together with the lachrymal duct remain patent, though the bony orifices are much reduced in size. There is a small conical closed sac, close to the septum at its fore part, which indicates the position of the now obliterated canal of Stenson. The termination is marked in the mouth by the incisive papilla. The membrane is continuous in front through the anterior nares with the skin; behind, it extends through the posterior nares to line the naso-pharynx, the Eustachian tube, the tympanum and the mastoid cells. It is intimately adherent to the periosteum and perichondrium. The acinous glands which are imbedded in its structure secrete for the most part a thin watery fluid. They are especially large over the inferior turbinal bone, and very numerous at the middle and back of the fossæ near the orifices of the posterior nares.

FIG. 516.—MUSCLES OF THE NOSE. (After Bourgery.)



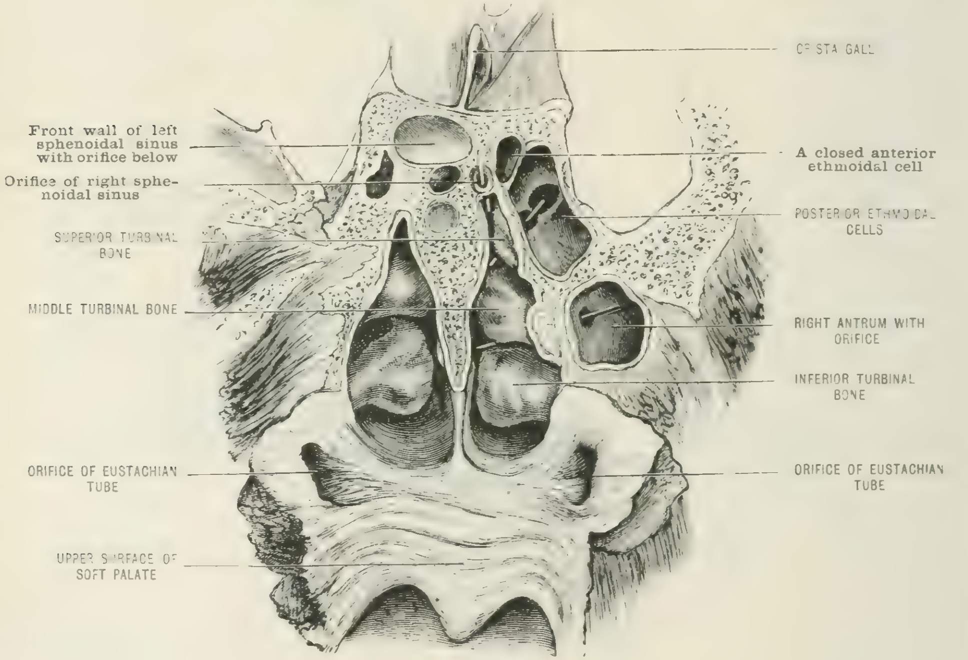
The **vestibule** is lined with a scaly epithelium; more posteriorly the nasal cavity is divided into an upper olfactory and a lower or respiratory region. The olfactory region is lined with a columnar unciliated epithelium. The mucous membrane is here of a yellowish colour, thicker than elsewhere, and contains the olfactory cells of Max Schultze.

The lower or respiratory is a much wider portion, in which the epithelium is columnar and ciliated, and includes the inferior turbinal bone with the lower part of the fossa.

Immediately behind the vestibule there are two shallow depressions separated by a ridge, the agger nasi, or naso-turbinal; the area below the ridge is the atrium of the middle meatus. It is bounded posteriorly by the anterior vertical border of the middle turbinal, beneath which it is continued into the middle meatus. The upper depression is the sulcus olfactorius; it leads upwards and backwards to the olfactory region of the nasal fossa.

The **roof** presents but one opening posteriorly, which leads into the sphenoidal sinus. The orifices in the cribriform plate are entirely closed over.

FIG. 517.—OBLIQUE SECTION PASSING THROUGH THE NASAL FOSSÆ, JUST IN FRONT OF THE POSTERIOR NARES. (Seen from behind.)


CRISTA GALLI
Front wall of left sphenoidal sinus with orifice below
A closed anterior ethmoidal cell
Orifice of right sphenoidal sinus
POSTERIOR ETHMOIDAL CELLS
SUPERIOR TURBINAL BONE
MIDDLE TURBINAL BONE
RIGHT ANTRUM WITH ORIFICE
INFERIOR TURBINAL BONE
ORIFICE OF EUSTACHIAN TUBE
ORIFICE OF EUSTACHIAN TUBE
UPPER SURFACE OF SOFT PALATE

In the **floor** the openings leading into the anterior palatine canal are closed. The small *cul-de-sac* already described indicates their position.

The **superior meatus** is the shortest of the three; it lies in the posterior third of the outer wall under cover of the superior turbinal bone, and it has but a single opening, which leads into the posterior ethmoidal cells. The spheno-palatine foramen is entirely covered by membrane.

The **middle meatus** lies in the posterior two-thirds of the nasal chamber under cover of the middle turbinal bone. On its outer wall is a rounded eminence, the bulla ethmoidalis, which is perforated by the aperture of the middle ethmoidal cells; and in front and below this is a curved groove, the sulcus semilunaris, which is continued above, by the infundibulum, into the frontal sinus; it receives the openings of the anterior ethmoidal cells and the antrum.

The **inferior meatus** is the longest of the three; it lies under cover of the inferior turbinal bone, and it receives the nasal duct anteriorly. The mucous membrane is arranged around the opening in a circular valve, the valve of Hasner, which is sometimes double (page 868).

FIG. 518.—SECTION OF THE NOSE, SHOWING THE TURBINAL BONES AND MEATUSES, WITH THE OPENINGS IN DOTTED OUTLINE.

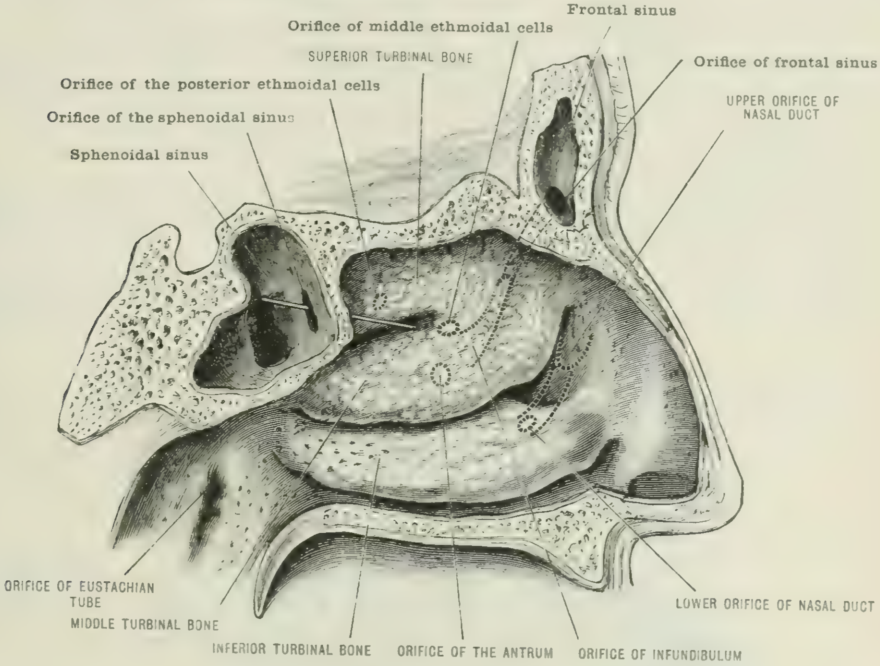
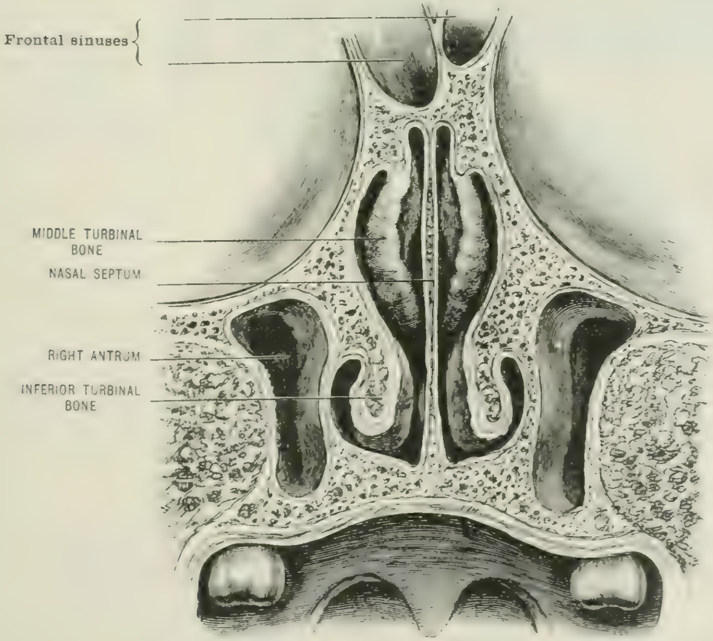

Frontal sinus
Orifice of middle ethmoidal cells
SUPERIOR TURBINAL BONE
Orifice of frontal sinus
Orifice of the posterior ethmoidal cells
UPPER ORIFICE OF NASAL DUCT
Orifice of the sphenoidal sinus
Sphenoidal sinus
ORIFICE OF EUSTACHIAN TUBE
MIDDLE TURBINAL BONE
INFERIOR TURBINAL BONE
ORIFICE OF THE ANTRUM
ORIFICE OF INFUNDIBULUM
LOWER ORIFICE OF NASAL DUCT

FIG. 519.—TRANSVERSE SECTION PASSING THROUGH THE NASAL FOSSÆ AND ANTRA AT THE POSTERIOR EXTREMITY OF THE MIDDLE TURBINAL BONE. (Seen from the front.)


Frontal sinuses
MIDDLE TURBINAL BONE
NASAL SEPTUM
RIGHT ANTRUM
INFERIOR TURBINAL BONE

The nerves.—The **olfactory** or **special nerves of smell,** the filaments of which pass through the foramina in the cribriform plate of the ethmoid bone, lie for some distance in the grooves of the bony walls before terminating in the Schneiderian membrane.

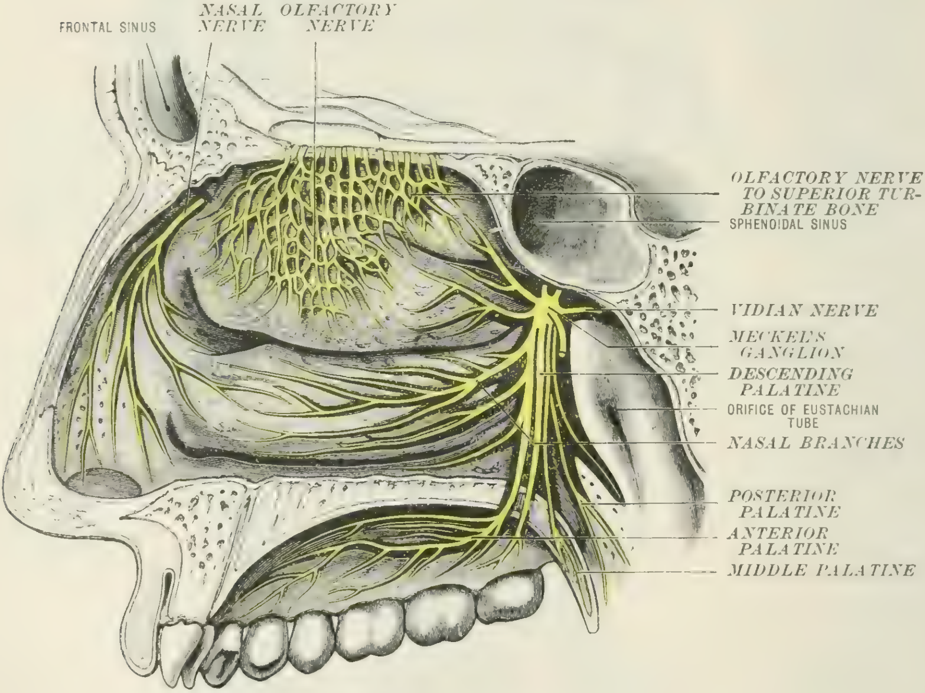
Those which supply the septum ramify in its upper fifth, whilst those which reach the outer walls are distributed in two groups—a **posterior,** to supply the membrane covering the superior turbinal bone, and an **anterior,** to ramify in the membrane over the middle turbinal bone and the smooth surface of the ethmoid in front of this.

In addition to the special nerves of smell, the cavity is supplied with nerves of **common sensation** derived from the **fifth pair.**

The **nasal branch of the ophthalmic** supplies the front and upper part of the septum, the anterior part of the roof and also the anterior part of outer wall of the nasal fossa.

The **Vidian,** with the **upper nasal branches of Meckel's ganglion,** supply the upper and back portion of the septum, the roof, and the outer wall, including the superior spongy bone.

FIG. 520.—NERVES OF THE NASAL CAVITY.


FRONTAL SINUS
NASAL NERVE
OLFACTORY NERVE
OLFACTORY NERVE TO SUPERIOR TURBINATE BONE
SPHENOIDAL SINUS
VIDIAN NERVE
MECKEL'S GANGLION
DESCENDING PALATINE
ORIFICE OF EUSTACHIAN TUBE
NASAL BRANCHES
POSTERIOR PALATINE
ANTERIOR PALATINE
MIDDLE PALATINE

The **naso-palatine** supplies the lower and posterior portion of the septum.

The **anterior dental branch of the maxillary division of the fifth nerve** is distributed to the anterior part of the inferior meatus and inferior turbinal bone.

The **anterior** or **large palatine nerve** supplies in its course downwards the posterior part of the middle and lower turbinal bones.

The **arteries** are distributed as follows:—

The **spheno-palatine,** from the internal maxillary by its **internal** or **naso-palatine branch,** supplies the **septum** as it courses downwards and forwards in the groove on the vomer to the incisor foramen. Its **external branches** supply the **antrum** (also supplied by the alveolar branch of the facial) and **frontal sinus,** the **ethmoidal cells,** and inner surfaces of the **turbinal bones** with the **meatuses.** It enters the cavity through the spheno-palatine foramen.

The **anterior** and **posterior ethmoidal arteries** derived from the ophthalmic supply the upper portion of the **septum,** the **roof,** the **outer wall** (anteriorly) and the **anterior** and **posterior ethmoidal cells.**

The **descending palatine** of the internal maxillary sends a few small branches to the back of the **inferior meatus** and **lower turbinal bone.**

The **Vidian** and **pterygo-palatine** supply the back part of the roof.

The branch to the septum derived from the superior coronary of the facial ramifies in the membrane covering its lower and front portion.

The veins form a plexus in the mucous membrane, especially marked at the lower and hinder portions of the fossa. The emissary trunks accompany the arteries, the spheno-palatine joins the pterygoid plexus, the ethmoidal pass to the ophthalmic vein but also have communications with the meningeal veins, and the anterior part of the plexus is drained by veins which pass forwards to terminate in the tributaries of the facial vein.

Communications are formed with the veins within the cranial cavity, through the cribriform foramina and foramen cæcum, and also with the facial vein through small foramina in the nasal bone and nasal process of the maxilla.

The **lymphatics** form a well-developed plexus, which communicates, through the lymphatics surrounding the olfactory nerves, with the subdural space within the cranial cavity, posteriorly with the pharyngeal lymphatics, and anteriorly with the lymphatics of the face.

SECTION VII

THE THORAX

INCLUDING THE ORGANS OF VOICE, RESPIRATION, AND CIRCULATION

By ARTHUR HENSMAN, F.R.C.S.

Revised for Second Edition by ARTHUR ROBINSON, M.D., M.R.C.S.

LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

THE THORAX

THE **thorax, or trunk of the body**—lying between the neck and the abdomen—is formed partly of bones and partly of soft connecting tissues. In the living body it is constantly varying in relation to the respiratory process. The cavity is bounded **in front** by the sternum and upper six costal cartilages and internal intercostal muscles; **behind** by the thoracic vertebræ and posterior ends of the ribs; and **laterally** by the ribs with the internal and external intercostal muscles.

Its form is conical, flattened in the adult from before backwards, so that its transverse is its greater diameter. In the human fœtus, as in the lower animals, it is flattened laterally, its antero-posterior diameter being the greater.

It is narrow above, where the ribs are short, and broad below. Owing to the backward set of the hinder extremities of the ribs, the bodies of the vertebræ project forwards into the cavity, which thus, on a transverse section, appears more or less cordiform.

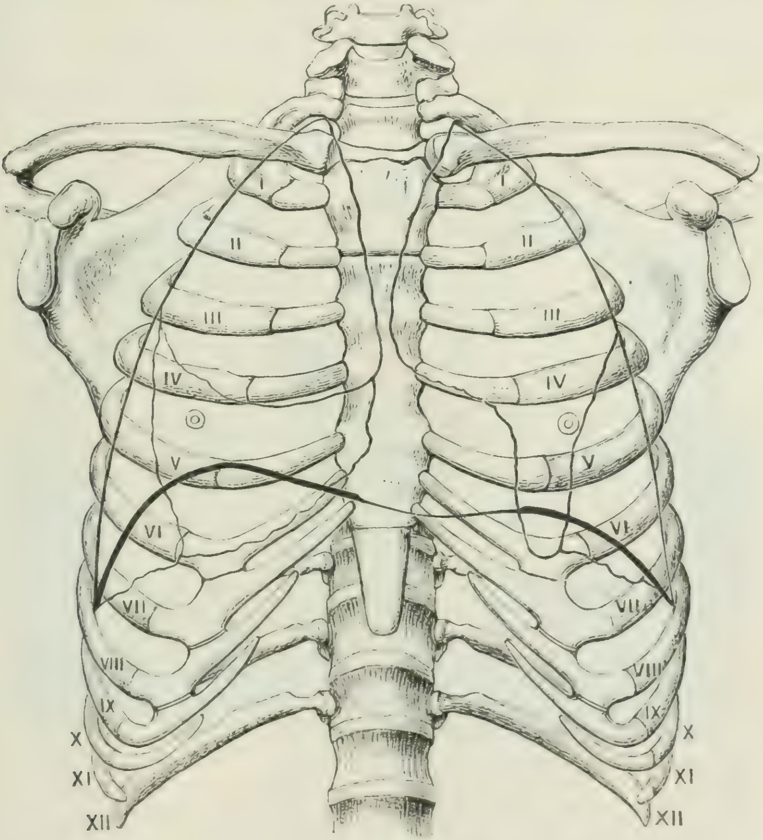
The **superior aperture** is bounded, **in front** by the upper margin of the sternum; **behind** by the body of the first thoracic vertebra; **on each side** by the first rib. It measures in a well-formed adult about two and a quarter inches from before backwards, and four and a quarter inches from side to side. The ribs slope downwards towards the sternum, the upper margin of which corresponds to the intervertebral substance between the second and third thoracic vertebræ. It transmits the following structures:—(1) The sterno-hyoid and sterno-thyroid muscles, and more deeply a thin layer of the deep cervical fascia which blends below with the sheath of the great vessels and the pericardium; (2) the thymus gland in the infant, or its shrunken remains in the adult; (3) an occasional middle thyroid artery, the trachea, the œsophagus, the thoracic duct, the longus colli muscles, and a thin layer of fascia overlying them. Laterally: the innominate artery (on the right side), the common carotid and subclavian (on the left), with the internal mammary and superior intercostal arteries; the innominate and inferior thyroid veins; the phrenic, pneumogastric, and sympathetic nerves, with the left recurrent laryngeal, some cardiac branches, and the anterior branches of the first thoracic nerve. On each side, in addition, there is a small portion of the apex of the lung with its pleural covering.

The **lower opening,** or **base,** is limited in front by the ensiform cartilage, behind by the twelfth thoracic vertebra, and laterally by the twelfth ribs.

The diaphragm arches upwards to form a vaulted floor to the intervening space. It is about one inch higher on the right side than on the left, and its flattened central portion is lower than either of the lateral arches. The thoracic cavity is much deeper behind than in front.

The following structures pass through the *lower* opening of the thorax:—(1) The aorta, vena azygos major, thoracic duct, the trunks of the efferent lymphatics from the lower intercostal spaces, and, occasionally, the left sympathetic nerve pass through the aortic opening. (2) The œsophagus, pneumogastric nerves, and some small œsophageal arterial branches emerge through the œsophageal opening.

FIG. 521.—ANTERIOR VIEW OF THE THORAX, WITH OUTLINES OF THE DIAPHRAGM AND LUNGS.



(3) The vena cava inferior ascends through the caval opening, and the branches of the phrenic nerves pierce the diaphragm to reach its lower surface.

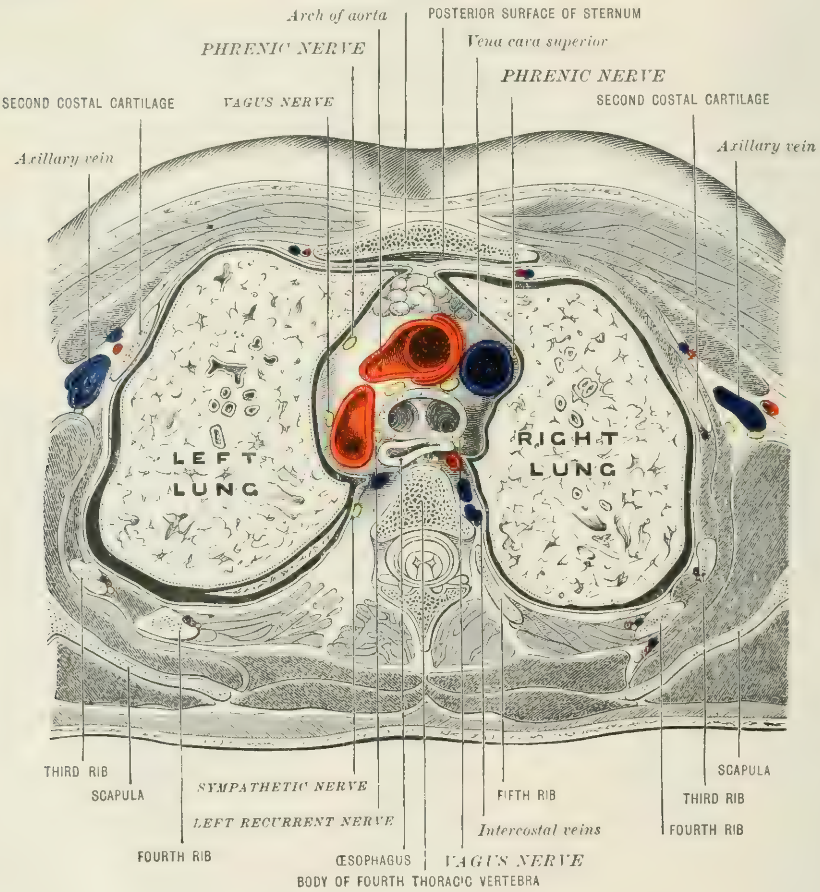
(4) The splanchnic nerves, the vena azygos minor, and the sympathetic trunk of each side pass through the crura.

The **viscera** contained within the thoracic cavity are: the **heart,** which is enclosed in the pericardium; and the **lungs,** with their pleural investments.

The heart lies between the lungs in the so-called **mediastinal space.** This is bounded on each side by the reflexions of the pleuræ, which pass from the front to the back of the thoracic cavity; and the common space is further subdivided into a **superior mediastinum** above the heart sac, an **anterior** and a **posterior** respectively in front of and behind it, and a **middle mediastinum** which contains the heart itself.

The **superior mediastinum** has the following boundaries:—the manubrium with the origins of the sterno-hyoid and sterno-thyroid muscles **in front**; the bodies of the four highest thoracic vertebræ **behind**, with the lower portions of the longus colli muscles; and **on each side** the pleural sacs. **Above,** the boundary corresponds with the superior aperture of the thorax, and **below** with a nearly horizontal plane passing backwards from the articulation between the manubrium and gladiolus of the sternum, to the lower part of the body of the fourth thoracic vertebra. This lower plane nearly corresponds with the upper part of the pericardium and roots of the lungs.

Fig. 522.—Superior View of a Section of the Thorax, passing through the Sternum immediately below the first Costo-sternal Articulation, through the Trachea at its division, and through the Body of the Fourth Thoracic Vertebra. (Braune.)


STERNUM
Arch of aorta
POSTERIOR SURFACE OF STERNUM
Vena cava superior
PHRENIC NERVE
PHRENIC NERVE
SECOND COSTAL CARTILAGE
VAGUS NERVE
SECOND COSTAL CARTILAGE
Axillary vein
Axillary vein
LEFT LUNG
RIGHT LUNG
THIRD RIB
SCAPULA
FOURTH RIB
SYMPATHETIC NERVE
LEFT RECURRENT NERVE
ŒSOPHAGUS
BODY OF FOURTH THORACIC VERTEBRA
VAGUS NERVE
Intercostal veins
FIFTH RIB
THIRD RIB
FOURTH RIB
SCAPULA

The superior mediastinum contains the thoracic portion of the trachea, œsophagus, thoracic duct, the arch of the aorta, the innominate artery, thyroidea ima, and thoracic portions of the left carotid and left subclavian; the innominate veins and upper part of the superior vena cava, the terminations of the inferior thyroid and internal mammary veins of both sides, and the superior intercostal vein of the left side; the two pneumogastric nerves, with the left recurrent, the phrenic and cardiac nerves; the thymus gland or its remains, and some bronchial lymphatic glands, with the superior sterno-pericardiac ligaments.

The **middle mediastinum** contains the heart, the ascending portion of the aorta and the pulmonary artery, the superior vena cava (lower half), all of which are placed within the pericardium; and in addition the phrenic nerves and their companion arteries, the termination of the azygos vein, the roots of the lungs, with some bronchial lymphatic glands.

The **anterior mediastinum** is narrow above, lying behind the sternum opposite the second, third, and fourth cartilages. Below, it opens out into a quadrangular space, having nearly the whole of the lower half of the sternum, the lower edge of the fourth, the fifth, part of the sixth, and the termination of the seventh cartilages of the left side, with the triangularis sterni muscle in front (fig. 521). The pericardium forms its posterior wall. The space merely contains some small lymphatic glands and areolar tissue, and a few irregular bands, the inferior sterno-pericardiac ligaments, with the thymus gland or its vestiges. It corresponds to the area of cardiac dullness.

The **posterior mediastinum** is bounded in front by the roots of the lungs and posterior surface of the pericardium, and behind by the thoracic vertebral column below the fourth thoracic vertebra. On each side it is bounded by the pleural sacs. It contains the descending aorta, œsophagus, and pneumogastric nerves, azygos veins, thoracic duct, and lymphatic glands.

THE ORGANS OF VOICE

THE LARYNX

The **larynx** is the organ of the voice, and the protector of the air passages from the intrusion of foreign bodies. By its closure, moreover, it retains the air within the chest cavity, contributing to the fixity of the thorax, a condition which is essential to the due performance of a variety of muscular actions.

It consists of a framework of cartilages held together by ligaments and acted upon by muscles (extrinsic and intrinsic). It is lined by a very sensitive mucous membrane, and supplied with blood-vessels, nerves, and lymphatics.

The **cartilages** of the larynx are nine in number. Some of these are single, some are arranged in pairs.

Single cartilages :—	**Paired cartilages :—**
Thyroid.	Arytenoid.
Cricoid.	Cornicula laryngis (Santorini).
Epiglottis.	Cuneiform (Wrisberg).

From their general structure they may be arrranged as follows:—

Hyaline :—	**Yellow elastic :—**
Thyroid.	Epiglottis.
Cricoid.	Cornicula laryngis.
Arytenoid (the tip of the arytenoid is yellow elastic).	Cuneiform.

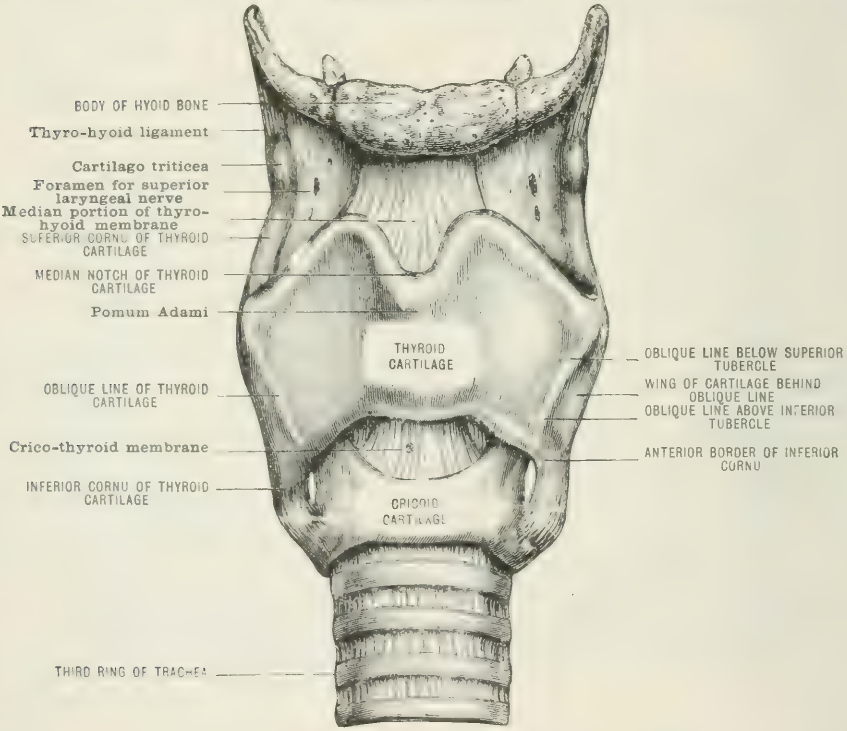
In the anteater there extends backwards from each side of the epiglottis to the summit of the arytenoids a continuous rim of yellow elastic cartilage. It is the broken remnant of this which in man forms the cornicula and the cuneiform cartilages. (Bland Sutton.)

The **THYROID CARTILAGE** forms the front and sides of the upper part of the larynx, being placed above the cricoid. It consists of two nearly square symmetrical plates, or alæ, united in front, where they form the pomum Adami, but widely separated behind. They include between them an angle varying from 80° to 90°, and are somewhat obliquely inclined, their outer surfaces looking slightly downwards as well as outwards. Each plate has an outer and an inner surface and four borders. The upper and lower posterior angles of each plate project upwards and downwards to form its superior and inferior cornua.

The **outer surface** is smooth, and is crossed by an oblique and often very faintly defined line, or by an occasional fibrous band. This is marked at each extremity by a small tubercle. These tubercles are more pronounced in old subjects. The line and the adjacent cartilage give attachments to the thyro-hyoid and sterno-thyroid muscles, and the inferior constrictor which overlaps the smaller portion of the ala lying behind the line.

The **inner surface** is also smooth; it is concave, and in contact with the mucous membrane which lines the sinus pyriformis, with branches of the laryngeal nerves and vessels, and with the external thyro-arytenoid and lateral crico-arytenoid muscles.

FIG. 523.—FRONT VIEW OF THE CARTILAGES OF THE LARYNX. (Modified from Bourgery and Jacob.)


BODY OF HYOID BONE
Thyro-hyoid ligament
Cartilago triticea
Foramen for superior laryngeal nerve
Median portion of thyro-hyoid membrane
SUPERIOR CORNU OF THYROID CARTILAGE
MEDIAN NOTCH OF THYROID CARTILAGE
Pomum Adami
THYROID CARTILAGE
OBLIQUE LINE OF THYROID CARTILAGE
Crico-thyroid membrane
INFERIOR CORNU OF THYROID CARTILAGE
CRICOID CARTILAGE
THIRD RING OF TRACHEA
OBLIQUE LINE BELOW SUPERIOR TUBERCLE
WING OF CARTILAGE BEHIND OBLIQUE LINE
OBLIQUE LINE ABOVE INFERIOR TUBERCLE
ANTERIOR BORDER OF INFERIOR CORNU

The **anterior** or **isthmic border**, which is also the shortest, corresponds to the junction of the two alæ in the median line in front; very prominent above, where it forms the **pomum Adami**, it becomes depressed before again projecting less markedly below. Posteriorly, at the angle of junction it gives attachment to the stalk of the epiglottis, the true and false vocal cords, the thyro-arytenoid and thyro-epiglottidei muscles.

The **superior border**, which gives attachment to the thyro-hyoid membrane, is sinuous. Slightly depressed posteriorly, it rises in front, and then becomes abruptly scooped out and everted to form the side of the great median notch.

The **inferior border** is somewhat sinuous. It gives attachment in front to the middle portion of the crico-thyroid membrane, and behind to the crico-thyroid muscle, and presents the small tubercle already noticed at the termination of the oblique line.

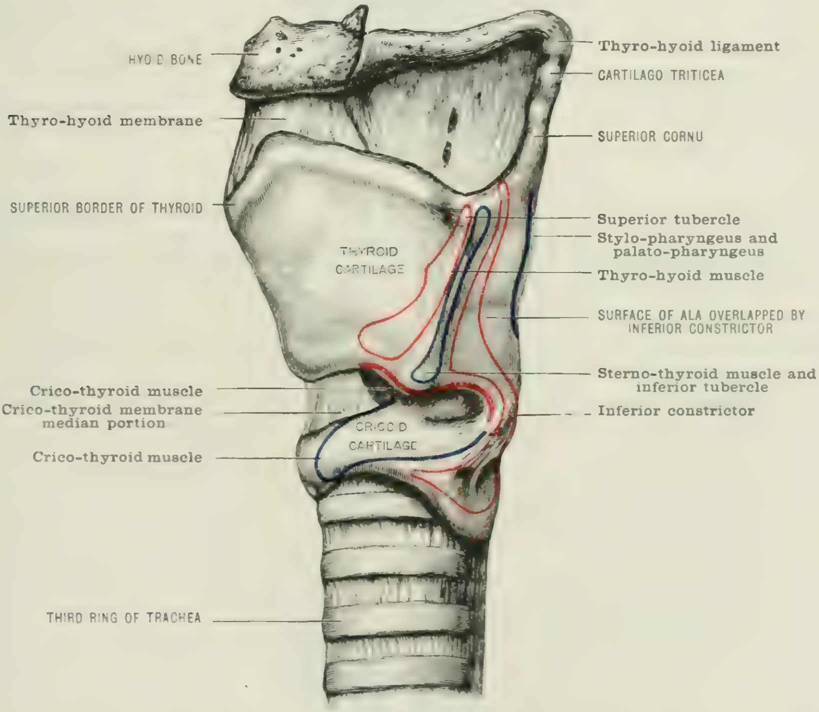
The **posterior border**, thick and rounded, projects above and below into the superior and inferior cornua, and gives partial insertion to the stylo- and palato-pharyngei muscles.

The **superior cornua** project inwards as well as upwards and backwards. To their tips are attached the thyro-hyoid ligaments, and near root of each appears the tubercle at the upper end of the oblique line.

The **inferior cornua** are short, blunt processes. They project inwards as well as downwards and forwards. By means of small oval concave facets (directed downwards as well as inwards) placed on their inner faces, the inferior cornua articulate with the facets on the sides of the cricoid cartilage. They give partial attachment to the inferior constrictors of the pharynx and crico-thyroid muscles in addition to the ligaments of the joint.

The **CRICOID CARTILAGE** is thick and strong, and forms a complete ring around the lower part of the larynx. Behind, it presents a quadrate surface, but narrows rapidly in its anterior half to only one-fourth or one-fifth of its posterior depth. Hence its comparison to a signet ring. It thus possesses an **anterior** and a **posterior portion**, and a **superior** and **inferior border**, and presents four articular surfaces.

FIG. 524.—SIDE VIEW OF THE CARTILAGES OF THE LARYNX. (Modified from Bourgery and Jacob.)


HYOID BONE
Thyro-hyoid membrane
SUPERIOR BORDER OF THYROID
THYROID CARTILAGE
Crico-thyroid muscle
Crico-thyroid membrane median portion
CRICOID CARTILAGE
Crico-thyroid muscle
THIRD RING OF TRACHEA
Thyro-hyoid ligament
CARTILAGO TRITICEA
SUPERIOR CORNU
Superior tubercle
Stylo-pharyngeus and palato-pharyngeus
Thyro-hyoid muscle
SURFACE OF ALA OVERLAPPED BY INFERIOR CONSTRICTOR
Sterno-thyroid muscle and inferior tubercle
Inferior constrictor

The **posterior quadrate portion** is divided behind by a median vertical ridge which separates two broad and shallow depressions. To this ridge some of the longitudinal fibres of the œsophagus are attached, and the depressions give origin to the posterior crico-arytenoid muscles.

The **anterior portion** is narrow and rounded, and gives attachment in front to the crico-thyroid muscles, and more posteriorly to some fibres of the inferior constrictor of the pharynx.

Between these two halves of the ring, but nearer the lower border, is placed the oval surface (looking upwards and outwards) for articulation with the inferior cornu of the thyroid cartilage.

The **inner surface** is smooth and lined by mucous membrane.

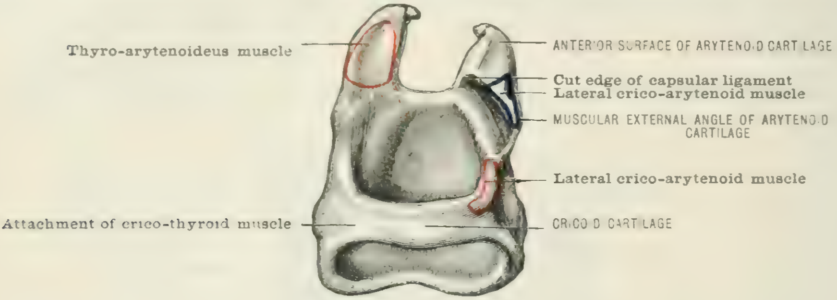
The **superior border** bounds the quadrate plate above, and then passes obliquely downwards and forwards. An oval, convex, obliquely placed articular surface, upon which moves the arytenoid cartilage, separates these two portions of the upper border on each side.

The oblique half gives attachment to the crico-thyroid membrane, and, laterally and external to this, to the lateral crico-arytenoid muscle.

The **inferior border**—horizontal, and often deeply notched at the sides—is attached to the first ring of the trachea by fibrous membrane.

The **arytenoid cartilages** are irregular, three-sided pyramids, which articulate by their bases with the oblique facets on the superior border of the cricoid cartilage, and support upon their apices the cornicula laryngis.

Fig. 525.—Front View of the Cricoid and Arytenoid Cartilages. (Modified from Bourgery and Jacob.)

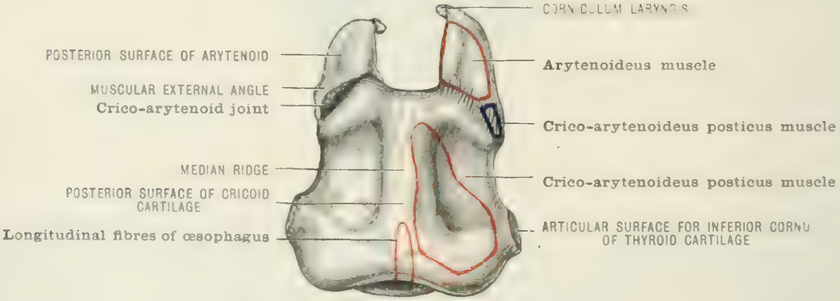

Thyro-arytenoideus muscle
ANTERIOR SURFACE OF ARYTENOID CARTILAGE
Cut edge of capsular ligament
Lateral crico-arytenoid muscle
MUSCULAR EXTERNAL ANGLE OF ARYTENOID CARTILAGE
Lateral crico-arytenoid muscle
Attachment of crico-thyroid muscle
CRICOID CARTILAGE

The space between them in certain animals has been likened to the mouth of a pitcher, and hence their name. Each cartilage presents **three surfaces,** divided by **three borders,** with a **base, apex,** and **angles.**

The surfaces.—The **posterior** is concave, smooth, and gives attachment to the arytenoid muscle.

The **anterior** is irregular and convex. It gives attachment by a small tubercle to the false vocal cord, and also to the thyro-arytenoid muscle.

Fig. 526.—Back View of the Cricoid and Arytenoid Cartilages. (Modified from Bourgery and Jacob.)


CORNICULUM LARYNGIS
POSTERIOR SURFACE OF ARYTENOID
Arytenoideus muscle
MUSCULAR EXTERNAL ANGLE
Crico-arytenoid joint
Crico-arytenoideus posticus muscle
MEDIAN RIDGE
Crico-arytenoideus posticus muscle
POSTERIOR SURFACE OF CRICOID CARTILAGE
Longitudinal fibres of œsophagus
ARTICULAR SURFACE FOR INFERIOR CORNU OF THYROID CARTILAGE

The **internal** is almost flat, smooth, and narrow, and covered by mucous membrane.

The **base** is obliquely hollowed, and presents internally the facet for articulation with the cricoid cartilage.

The angles.—The **anterior** is prolonged for the attachment of the true vocal cord. It is known as the vocal process, and with the aid of the laryngoscope is easily seen during life.

The **external** or **muscular** is thick and blunt, and gives attachment in front to the lateral crico-arytenoid, and behind to the posterior crico-arytenoid muscle.

The **internal** is unimportant; it is tied to the corresponding cartilage and to the cricoid by a fibrous band which is known as the transverse or crico-arytenoid ligament.

The borders.—The two **internal**, which limit the narrow inner face, are nearly parallel and almost vertical; whilst the **external** slopes upwards, inwards, and backwards.

The **apex** projects inwards and backwards, and supports the corniculum. The cartilage here becomes fibrous in structure.

The **EPIGLOTTIS** is a median leaf-like plate of yellow elastic cartilage attached by a stalk inferiorly to the retiring angle of the thyroid cartilage below the median notch. When denuded of its mucous covering, it is seen to be pitted with numerous depressions for the lodgment of glands (fig. 530).

Placed with its lingual surface above, and its stalk in front, it has been compared to an elongated saddle. It varies very considerably both in shape and inclination, its leaf-like portion being sometimes considerably curled upon itself. It is placed nearly vertically in the adult, but in children is frequently so much depressed that its posterior free surface is inclined below its anterior. Hence its variable appearance when examined in the living subject with the laryngoscope. It is somewhat depressed and folded upon itself during deglutition.

Its anterior or lingual aspect is free above and covered with mucous membrane, which lower down is reflected forward upon the base of the tongue in three folds—one median (which encloses elastic tissue) and two lateral—the **glosso-epiglottidean folds.** Beneath the mucous membrane the deeper attached portion of this surface is tied to the hyoid bone by a median elastic membrane, named **hyo-epiglottidean ligament,** and by small bands of muscular fibres.

A quantity of elastic and fatty tissue, closely blended with the hyo-epiglottidean ligament above, connects the epiglottis to the thyro-hyoid membrane in front. This is known as the **periglottis** (fig. 528). Still lower, the fibro-elastic tissue which forms the thyro-epiglottidean ligament attaches the stalk to the thyroid cartilage.

The posterior or laryngeal surface, concavo-convex from above downwards, and concave from side to side, is free and covered with mucous membrane for its whole extent. About its centre it projects backwards to form the **cushion of the epiglottis.**

The lateral margins, which are free above, give attachment below to the **aryteno-epiglottidean folds** of mucous membrane which form the boundaries of the superior aperture of the larynx, and also on each side to a fold of the membrane, containing fibrous tissue, which runs upwards to the posterior pillar of the fauces—the **pharyngo-epiglottidean fold.**

The **CORNICULA LARYNGIS,** or **cartilages of Santorini,** are the two little cone-shaped yellow elastic cartilages which project backwards and inwards from the summits of the arytenoids, with which they are sometimes directly continuous. A joint, however, is usually present.

The **CUNEIFORM CARTILAGES,** or **cartilages of Wrisberg,** are placed within the aryteno-epiglottidean folds. These small conical and elongated yellow elastic cartilages produce the thickenings of the folds in front of the cornicula.

Calcification.—The hyaline cartilages of the larynx are especially prone to calcify after middle life, but the yellow elastic cartilages take no share in the process. The little **cartilago triticea,** however, which lies in the thyro-hyoid ligament, is frequently converted into bone.

In the thyroid cartilage the deposit of bony salts usually commences near the posterior border and in the cornua, extending forwards into the lower part of the ala, and finally upwards, until in advanced cases the whole cartilage is involved.

In the cricoid cartilage the calcification commences above on each side in the neighbourhood of the crico-arytenoid joints, and extends downwards, and finally both forwards and backwards.

In the arytenoid the calcification commences in the base, but it finally involves the whole cartilage with the exception of the summit, where the hyaline structure (as already noted) disappears.

The ligaments (**extrinsic**).—The **thyro-hyoid membrane** is composed mainly of elastic fibres. It is attached below to the upper margin of the thyroid cartilage, and above to the upper and hinder margin of the hyoid bone. It presents a thick central portion (stretching between the median notch and the body of the hyoid bone), and thinner lateral portions, looser in texture, which are pierced by the superior laryngeal nerves and arteries. Posteriorly, the membrane is loosely connected with the superior cornua of the thyroid cartilage, and above these it is bounded on each side by thickened bands, the **thyro-hyoid ligaments,** which pass between their tips and the greater cornua of the hyoid bone.

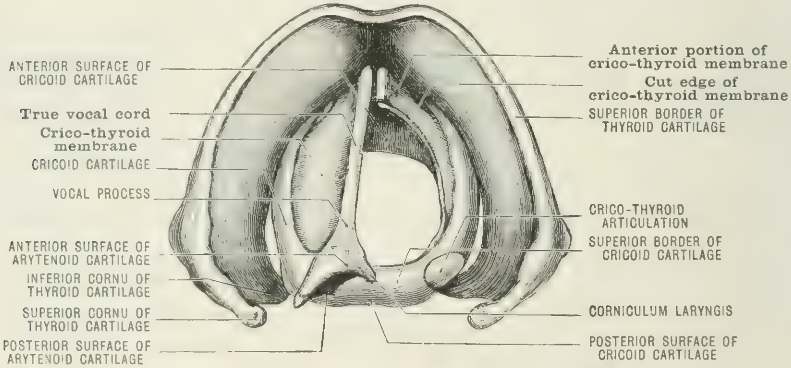
A little grain-like cartilage (cartilago triticea) is usually imbedded in this band just above the superior thyroid cornu.

The central portion of the membrane is mainly subcutaneous, a bursa intervening where it is overhung by the body of the hyoid bone.

Its lateral portions are covered by the thyro-hyoid muscles. Posteriorly it is separated from the epiglottis by the mucous membrane at the base of the tongue and the areolar fatty tissue already described. It is pierced by the internal laryngeal vessels and nerves.

The **crico-thyroid membrane (intrinsic)** is composed chiefly of elastic tissue. It presents a prominent rounded median portion overlapped slightly by the crico-thyroid muscles, but between these muscles it is subcutaneous. It is crossed by a small anastomotic arch formed by the crico-thyroid twigs of the superior laryngeal artery; one or two small holes, which pass through it, transmit vessels from the arch to the interior of the larynx.

FIG. 527.—SUPERIOR VIEW OF THE CARTILAGES OF THE LARYNX.


ANTERIOR SURFACE OF CRICOID CARTILAGE
True vocal cord
Crico-thyroid membrane
CRICOID CARTILAGE
VOCAL PROCESS
ANTERIOR SURFACE OF ARYTENOID CARTILAGE
INFERIOR CORNU OF THYROID CARTILAGE
SUPERIOR CORNU OF THYROID CARTILAGE
POSTERIOR SURFACE OF ARYTENOID CARTILAGE
Anterior portion of crico-thyroid membrane
Cut edge of crico-thyroid membrane
SUPERIOR BORDER OF THYROID CARTILAGE
CRICO-THYROID ARTICULATION
SUPERIOR BORDER OF CRICOID CARTILAGE
CORNICULUM LARYNGIS
POSTERIOR SURFACE OF CRICOID CARTILAGE

This median portion of the membrane stretches between the borders of the two cartilages. The lateral and thinner portions pass upwards from the inner border of the upper margin of the cricoid cartilage in contact with the laryngeal mucous membrane, and within the embrace of the thyroid cartilage, to form the **true vocal cords** or **inferior thyro-arytenoid ligaments.** These elastic bands extend from the vocal processes of the arytenoid cartilages to the retiring angle of the thyroid near its centre.

The lateral portions of this membrane are covered superficially by the thyro-arytenoid and lateral crico-arytenoid muscles.

The **superior thyro-arytenoid ligaments** are contained within the arched folds of mucous membrane which form the false vocal cords. They consist of a few bundles of fibrous tissue.

The **crico-arytenoid** or **transverse ligament** has been already sufficiently noticed.

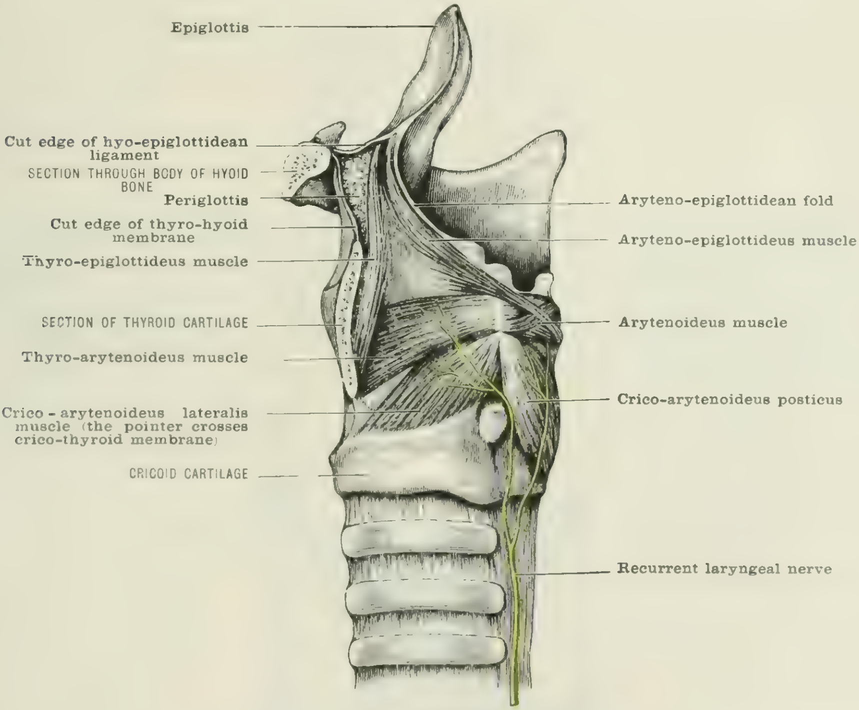
The Joints of the Larynx.—The **crico-thyroid joints** are lined by a synovial membrane, embraced by a thin capsule of radiating fibres, and often strengthened posteriorly by a well-marked fibrous band. They permit of movement between the two cartilages upon an axis passing transversely through both joints, and a limited gliding of the cricoid upwards and backwards. As can be shown on the living body, the cricoid is the cartilage which swings between the inferior thyroid cornua.

The **crico-arytenoid joints** possess a synovial membrane enveloped in a thin and moderately loose capsule, strengthened posteriorly by a band passing between the cricoid and the inner and back part of the arytenoid—the **posterior crico-arytenoid ligament**; and internally by the interarytenoid band, which is occasionally ligamentous—the **crico-arytenoid ligament.**

The cricoid articular surface is oval, convex, and oblique, with its long axis passing from behind, forwards, and outwards. The opposed articular surface on the base of the arytenoid is also oval, but it is concave with its long axis passing from before backwards.

It follows that the two surfaces never completely cover each other at any one time. The arytenoid **rotates** on a vertical axis near to and parallel with its inner surface, and it also **glides** forwards and inwards, or in an opposite direction. These movements are associated—the gliding forwards and inwards with the inward rotation, and the gliding outwards and backwards with the outward rotation.

FIG. 528.—SIDE VIEW OF THE MUSCLES AND LIGAMENTS OF THE LARYNX.


Epiglottis
Cut edge of hyo-epiglottidean ligament
SECTION THROUGH BODY OF HYOID BONE
Periglottis
Cut edge of thyro-hyoid membrane
Thyro-epiglottideus muscle
SECTION OF THYROID CARTILAGE
Thyro-arytenoideus muscle
Crico-arytenoideus lateralis muscle (the pointer crosses crico-thyroid membrane)
CRICOID CARTILAGE
Aryteno-epiglottidean fold
Aryteno-epiglottideus muscle
Arytenoideus muscle
Crico-arytenoideus posticus
Recurrent laryngeal nerve

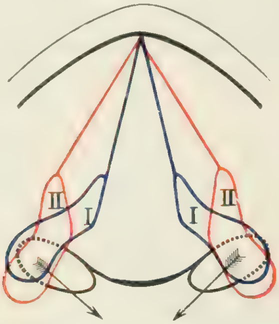
The Muscles.—The muscles are divisible into an extrinsic group, passing between the larynx and parts beyond; and an intrinsic group, belonging entirely to the organ itself.

The **extrinsic muscles** are the sterno-thyroid, thyro-hyoid, stylo- and palato-pharyngei, and the inferior constrictors of the pharynx. It should be noted that the muscles which fix the hyoid bone, and also those which close the lower jaw, assist the action of the above mentioned.

The intrinsic muscles.—The **crico-thyroid** is attached below to the front and side of the cricoid cartilage, and above to the lower border of the thyroid cartilage. The lower fibres, which are horizontal and often distinct, pass to the front border of its inferior cornu, and act by pulling the cricoid directly backwards, whilst the spreading fibres which form the rest of the muscle swing the cricoid between the crico-thyroid joints, pulling it upwards as well as backwards. Both portions of the muscle make tense the vocal cords, and are supplied by the external laryngeal nerve. It is overlapped laterally by the sterno-thyroid, having beneath it a small portion of the crico-thyroid membrane and some of the lower fibres of the lateral crico-arytenoid muscle. The central portion of the crico-thyroid membrane appears in the angular interval between the two muscles.

The **crico-arytenoideus posticus** arises from the quadrate surface situated on each side of the posterior median ridge of the cricoid cartilage. Its fibres rapidly converge to be inserted into the posterior portion of the outer angle (muscular process) of the arytenoid cartilage.

FIG. 529.—SCHEME OF RIMA, SHOWING ACTION OF CRICO-ARYTENOIDEUS POSTICUS, WHICH DRAWS THE ARYTENOID CARTILAGE FROM I TO II. (Modified from Stirling.)

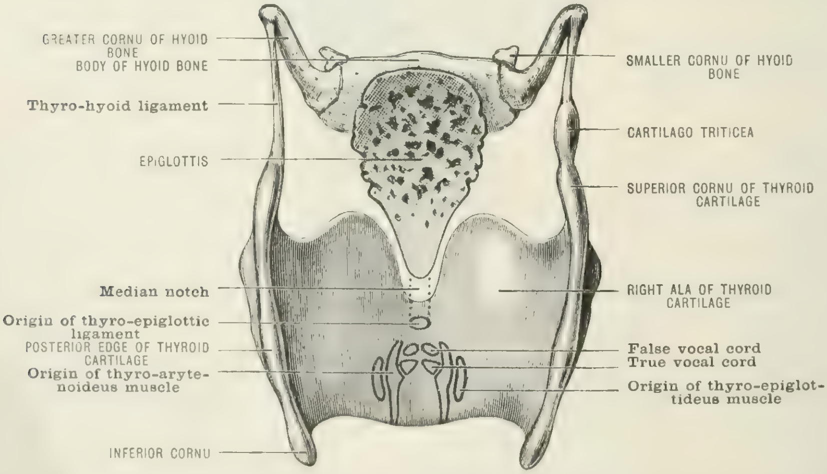


The upper fibres are chiefly concerned in rotation of the arytenoid cartilage, whilst the lower produce its gliding movement. It is a dilator of the rima glottidis.

Some of the lowest fibres occasionally pass to the inferior cornu of the thyroid cartilage, and are known as the kerato-cricoideus or kerato-thyroideus.

It is covered posteriorly by mucous membrane, and is supplied by the recurrent laryngeal nerve. A few of the longitudinal fibres of the œsophagus arise from the ridge which separates the two muscles.

FIG. 530.—POSTERIOR VIEW OF THYROID CARTILAGE WITH EPIGLOTTIS.

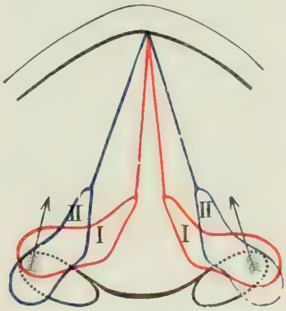

GREATER CORNU OF HYOID BONE
BODY OF HYOID BONE
Thyro-hyoid ligament
EPIGLOTTIS
Median notch
Origin of thyro-epiglottic ligament
POSTERIOR EDGE OF THYROID CARTILAGE
Origin of thyro-arytenoideus muscle
INFERIOR CORNU
SMALLER CORNU OF HYOID BONE
CARTILAGO TRITICEA
SUPERIOR CORNU OF THYROID CARTILAGE
RIGHT ALA OF THYROID CARTILAGE
False vocal cord
True vocal cord
Origin of thyro-epiglottideus muscle

The **crico-arytenoideus lateralis** arises from the upper border of the cricoid cartilage between the origin of the crico-thyroid and the crico-arytenoid articulation. It narrows to be inserted into the fore part of the muscular process of the arytenoid cartilage. It draws the cartilage forwards, relaxing and approximating the cords.

It is overlapped by the thyroid cartilage, and anteriorly by the crico-thyroid muscle; internally it is covered by mucous membrane. The upper portion is contiguous to the thyro-arytenoid, with which it is occasionally blended. It is supplied by the recurrent laryngeal nerve.

The **thyro-arytenoid muscle,** which is placed above the foregoing, arises broadly from the lower two-thirds of the inner surface of the thyroid cartilage close to its retiring angle, and slightly from the external surface of the crico-thyroid membrane. Narrowing as it passes outwards and backwards, it is inserted into the anterior surface of the arytenoid cartilage, and also into its base close to the attachment of the lateral crico-arytenoid muscle. Some few of its fibres pass onwards and become continuous with the oblique fibres of the arytenoid muscle.

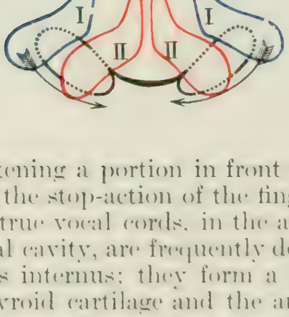
FIG. 531.—SCHEME SHOWING ACTION OF THYRO-ARYTENOID DRAWING THE VOCAL CORDS AND VOCAL PROCESSES FROM II TO I. (Modified from Stirling.)



The lower portion of the muscle lies parallel to and blends with the outer surface of the vocal cord. The upper and thinner portion is placed immediately beneath the mucous membrane, and overlies the ventricle and laryngeal pouch.

These muscles by rotating the arytenoid cartilages draw the vocal processes downwards and inwards, and thus approximate the vocal cords. By pulling forward the cartilages, they relax the cord as a whole. According to some authorities, the fibres attached to the outer border of the vocal cord act upon it by modifying its elasticity, tightening a portion in front and relaxing the remainder, in this somewhat resembling the stop-action of the finger on a violin string.

FIG. 532.—SCHEME SHOWING ACTION OF ARYTENOIDEUS DRAWING ARYTENOID CARTILAGE FROM NEUTRAL POSITION I TO II. (Modified from Stirling.)



The fibres lying near the true vocal cords, in the angle between the middle and lower sections of the laryngeal cavity, are frequently described as a separate portion called the thyro-arytenoideus internus; they form a triangular prismatic bundle, attached anteriorly to the thyroid cartilage and the anterior part of the true vocal cord, and posteriorly to the arytenoid cartilage in the neighbourhood of the vocal process. The remainder of the muscle, the thyro-arytenoideus externus, is a broad, flat band which intervenes between the ventricle of the larynx and the inner surface of the thyroid cartilage.

The **arytenoideus** consists of transverse fibres passing from one arytenoid cartilage to the other, and attached to their posterior concave surfaces. Superficially are some oblique fibres, which decussate where they meet. These pass from the outer angle of one cartilage below to the summit of the opposite. A few of these fibres pass onwards to the aryteno-epiglottidean fold and side of epiglottis. These, reinforced by fibres attached to the summit of the arytenoid cartilage, constitute the **aryteno-epiglottideus muscle.** A few fibres blend with the thyro-arytenoid muscle.

The arytenoideus approximates and depresses the arytenoid cartilages. These actions are assisted by the aryteno-epiglottidei, which depress the epiglottis and contract the superior aperture of the larynx.

The **thyro-epiglottideus** (sometimes described as part of the thyro-arytenoid) consists of fibres attached below to the thyroid cartilage which, spreading above, reach the aryteno-epiglottidean fold, and the outer wall of the laryngeal pouch as well as the epiglottis. (For the nerve-supply of the laryngeal muscles see page 912.)

The Interior of the Larynx.—The **superior aperture,** or **opening of the glottis,** is triangular in shape, wide in front, narrow behind, and placed so obliquely as to be almost vertical in the living subject. Above and in front it is bounded by the epiglottis, behind and below by the interarytenoid notch, whilst on each side stretches the aryteno-epiglottidean fold containing muscular and ligamentous fibres. This fold presents two thickened areas, one at the summit of the arytenoid cartilage, and one just in front and above this, formed by the bulging of the cornicular and cuneiform cartilages respectively.

Bounded internally by this fold, and externally by the wing of the thyroid cartilage, is a shallow depression—the **sinus pyriformis.**

The cavity of the larynx extends from the aperture above described to the lower border of the cricoid cartilage.

Its lining of **mucous membrane** varies much in its colour and thickness and its fixity to the structures which it overlies. On the surface of the true vocal cords it is extremely thin, pale and adherent, whilst above and below this it is more vascular and more loosely attached to the underlying parts. The submucous tissue contains numerous elastic fibres and mucous glands.

The cavity is naturally divided into two portions—**supra-** and **infra-rimal**—divided by the glottis or interval between the two true vocal cords.

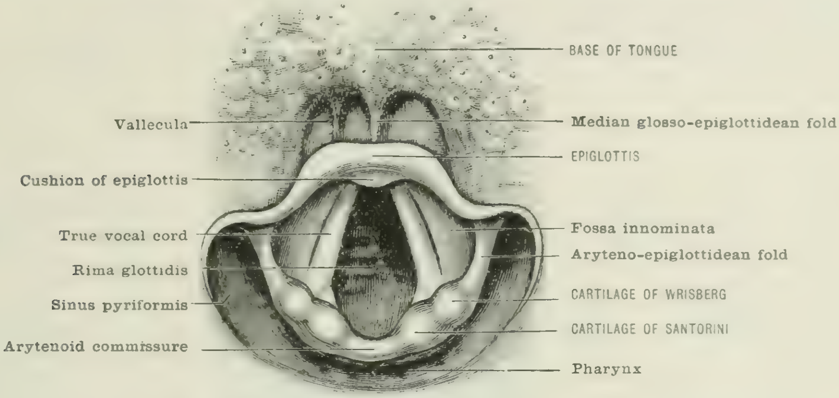
The **suprarimal portion** corresponds to the space between the wings of the thyroid cartilage. It is broad and triangular above, but narrower below, and its walls are much deeper in front than behind. Immediately above each vocal cord is an oblong depression—the **ventricle**—bounded above by the crescent-shaped edge of the false vocal cord, below by the straight margin of the true vocal cord, and externally by the thyro-arytenoid muscle. The ventricle extends nearly the whole length of the vocal cords, and is lined by a thin and tightly adherent mucous membrane. It allows the free vibration of the true vocal cords in the production of sound. From the anterior part of the ventricle there extends upwards, for about half an inch, a small blind sac, named the **laryngeal pouch.** This reaches as high as the upper border of the thyroid cartilage; its mouth below is narrow and guarded by two little folds of mucous membrane. A delicate fibrous investment is continued from the true vocal cord around the sac. Some fatty tissue is enclosed within this, and its mucous lining contains numerous glands. On its outer side are some fibres of the thyro-arytenoid muscle; whilst on its inner side is a thin layer of muscular fibres, derived from the aryteno-epiglottideus, and sometimes known as Hilton's muscle, or the **compressor sacculi laryngis.**

The **superior** or **false vocal cords** stand farther apart than the true, and cannot be made absolutely tense. They have already been sufficiently described. A shallow fossa—the **fossa innominata**—is observable, especially during phonation, between the false cord and the aryteno-epiglottidean fold; it is placed a little behind the epiglottis.

The **inferior** or **true vocal cords** are the structures concerned in the production of the voice. They stretch from the vocal processes of the arytenoid cartilages to the thyroid cartilage, their tension and position varying under muscular action. The cords are pearly white in appearance, and present flattened surfaces where they face each other internally, with a free sharp edge above. It is this edge which is thrown into vibrations during phonation.

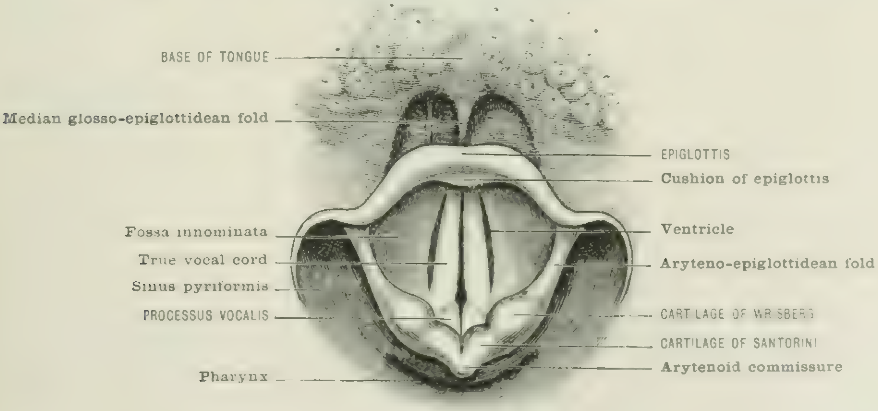
They are, according to Testut, about four-fifths to one inch long (20 to 24 mm.), in the male, and three- to four-fifths of an inch (15 to 20 mm.) in length, in the female.

FIG. 533.—VIEW OF INTERIOR OF LARYNX AS SEEN DURING INSPIRATION.


BASE OF TONGUE
Vallecula
Median glosso-epiglottidean fold
EPIGLOTTIS
Cushion of epiglottis
True vocal cord
Fossa innominata
Aryteno-epiglottidean fold
Rima glottidis
Sinus pyriformis
CARTILAGE OF WRISBERG
CARTILAGE OF SANTORINI
Arytenoid commissure
Pharynx

The **rima glottidis** is the chink bounded on each side by the vocal cords and the inner surfaces of the arytenoid cartilages with their vocal processes; the intercordal portion is known as the glottis vocalis, and the interarytenoid part as the glottis respiratoria; the length of the former is the same as that of the vocal cords, and that of the latter is about a quarter of an inch (6 to 7 mm.) in the male and 5 to 6 mm. in the female. (Testut.)

FIG. 534.—VIEW OF INTERIOR OF LARYNX AS SEEN DURING VOCALISATION.


BASE OF TONGUE
Median glosso-epiglottidean fold
EPIGLOTTIS
Cushion of epiglottis
Fossa innominata
Ventricle
True vocal cord
Aryteno-epiglottidean fold
Sinus pyriformis
PROCESSUS VOCALIS
CARTILAGE OF WRISBERG
CARTILAGE OF SANTORINI
Arytenoid commissure
Pharynx

It is limited behind by the interarytenoid fold, and presents the appearance of an elongated triangle.

When observed during life, the rima glottidis is seen to vary very considerably. On inspiration the vocal cords, whilst almost touching in front, are separated behind from a quarter to half an inch (6 to 12 mm.), forming an angle directed outwards, where they terminate in the vocal processes, the glottis presenting a lozenge-shaped appearance.

On phonation the cords become parallel and closely approximated, and the vocal processes approaching each other cause the angle to be turned inwards.

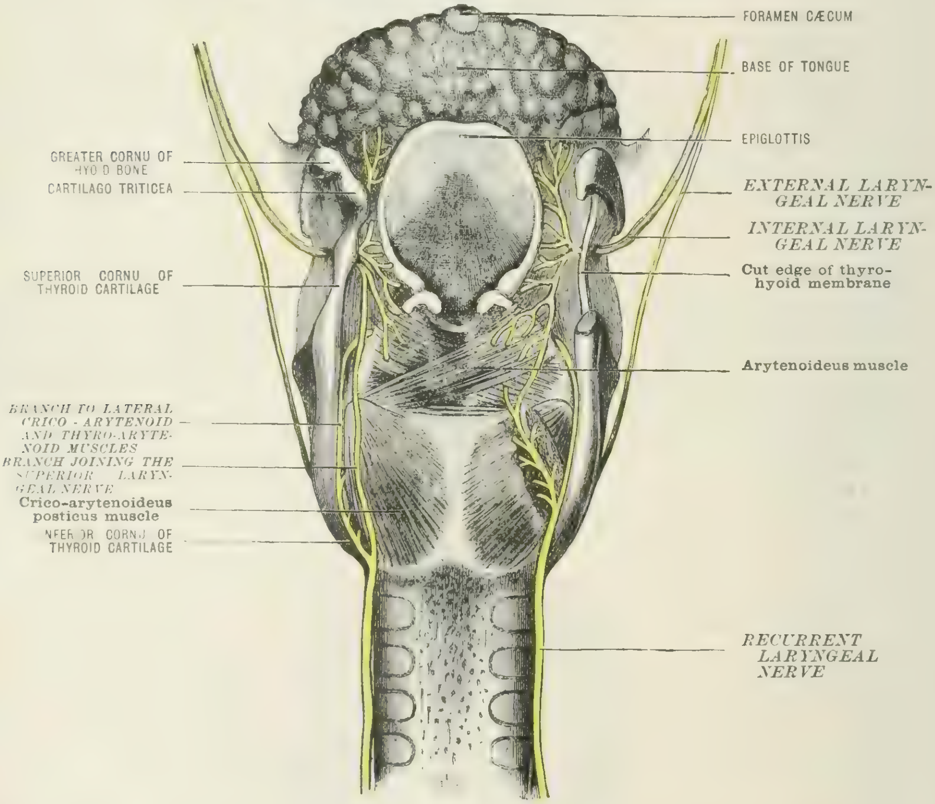
The **infrarimal portion** of the larynx rapidly widens out into a nearly circular cavity at the lower border of the cricoid cartilage, from which point it is continuous with the lumen of the trachea.

Nerves.—The nerves of the larynx are derived from the superior and inferior (recurrent) laryngeal branches of the vagus.

The superior laryngeal.—The sensory nerve of the larynx gives off near its origin behind the carotid sheath a long and slender filament, which is principally motor. This (**external**) branch is distributed to the crico-thyroid muscle, a few minute filaments reaching the mucous membrane of the larynx.

Its larger and main branch (**internal**) is sensory, and passes through the aperture in the thyro-hyoid membrane above the superior laryngeal artery. It divides beneath the mucous membrane which lines the sinus pyriformis, distributing branches upwards to supply both surfaces of the epiglottis and the base of the tongue immediately in front; inwards to the aryteno-epiglottidean fold and its neighbourhood; whilst others pass downwards to the mucous membrane of the deeper portions of the larynx as far as the true vocal cords.

FIG. 535.—NERVES OF THE LARYNX. (Posterior view.)


FORAMEN CÆCUM
BASE OF TONGUE
EPIGLOTTIS
GREATER CORNU OF HYOID BONE
CARTILAGO TRITICEA
EXTERNAL LARYNGEAL NERVE
INTERNAL LARYNGEAL NERVE
Cut edge of thyro-hyoid membrane
SUPERIOR CORNU OF THYROID CARTILAGE
Arytenoideus muscle
BRANCH TO LATERAL CRICO - ARYTENOID AND THYRO-ARYTENOID MUSCLES
BRANCH JOINING THE SUPERIOR LARYNGEAL NERVE
Crico-arytenoideus posticus muscle
INFERIOR CORNU OF THYROID CARTILAGE
RECURRENT LARYNGEAL NERVE

The **inferior (recurrent) laryngeal,** the motor nerve of the larynx, ascends in the groove between the trachea and œsophagus, both of which structures it supplies. It reaches the larynx below the edge of the inferior constrictor, and immediately behind the crico-thyroid joint. At this spot it divides into two branches: an **anterior** to supply the thyro-arytenoideus, crico-arytenoideus lateralis, with the muscles of the epiglottis; and a **posterior branch** to the crico-arytenoideus posticus and arytenoideus.

The superior laryngeal communicates with this branch by a slender filament, which passes downwards near to the posterior border of the thyroid cartilage. This communication sometimes takes place beneath the posterior crico-arytenoid muscle.

The **arteries** are derived from the superior and inferior thyroid, the epiglottis receiving some twigs from the dorsalis linguæ of the lingual.

The **veins** correspond with the arteries; and the **lymphatics**, which are scanty, follow the vessels and end in the deep cervical glands.

THE TRACHEA

The **trachea,** or **air-tube,** which is cylindrical in shape, but flattened posteriorly, extends from the lower border of the fifth cervical vertebra to the fourth or fifth thoracic vertebra. It is continuous with the larynx above, and divides into the two bronchi below. It measures from four and a half to five inches (10 to 12 cm.) in length, and is nearly an inch (2·5 cm.) in width.

Relations.—In its **cervical portion** it rests upon the œsophagus, which curves somewhat to the left at the root of the neck; on each side, but especially on the left, it comes into relationship with the lateral lobes of the thyroid gland, the inferior thyroid arteries, and the recurrent laryngeal nerves (these latter running upwards gain the lateral groove between the trachea and œsophagus); and lastly, it is in relation with the sheath containing the common carotid artery, internal jugular vein, and pneumogastric nerve.

In front it is crossed, opposite the second, third, and fourth rings, by the isthmus of the thyroid body; above the isthmus it is concealed in part by the pyramidal lobe of the thyroid and by the levator glandulæ thyroideæ muscle, and it is crossed by the internal terminal branches of the superior thyroid arteries. Below the isthmus the inferior thyroid veins, the thyroidea ima artery, if it is present, and the remains of the thymus gland lie in close relation with it, and more anteriorly, separated from it by the deep cervical fascia, are the anterior jugular veins and their anastomosis above the sternum.

It is overlapped on each side by the sterno-hyoid, sterno-thyroid, and sterno-mastoid muscles, and the interval between the muscles of the two sides is crossed by a strong deep and a thinner superficial layer of deep cervical fascia, whilst still more superficially lie the superficial fascia and skin.

In its **thoracic portion** the trachea still rests upon and retains its connection with the œsophagus, which separates it from the spine. It lies between the two pleural sacs and pneumogastric nerves.. In front of it is the sternum with the origins of the sterno-hyoid and sterno-thyroid muscles, the thymus gland, the deep cardiac plexus, the aortic arch which crosses the tube just above its bifurcation, the commencements of the innominate and left common carotid arteries and the left innominate vein which crosses the roots of the latter vessels. On its right side are the pleural sac, the vagus nerve, and the innominate artery, and on its left side the left common carotid and subclavian arteries, the left vagus and left recurrent nerves, and the left pleural sac.

Structure.—The trachea is made up of a series of imperfect cartilaginous rings, deficient behind, connected throughout by fibro-elastic membrane, and behind with muscular fibres (the trachealis muscle), a special layer of yellow elastic fibres, and a lining of mucous membrane.

The **cartilaginous rings** vary in number from sixteen to twenty. They are incomplete, being deficient in the hinder third, and are connected in a continuous series by a **fibrous membrane,** which divides to enclose them, but reunites in the narrow intervals between. It forms a definite layer where the cartilages are wanting, so that it may be regarded as complete throughout the tube. The inside of the trachea is ridged transversely by the rings, which are rounded on their inner surfaces; but it is comparatively smooth externally, where the outer surfaces of the rings are flattened.

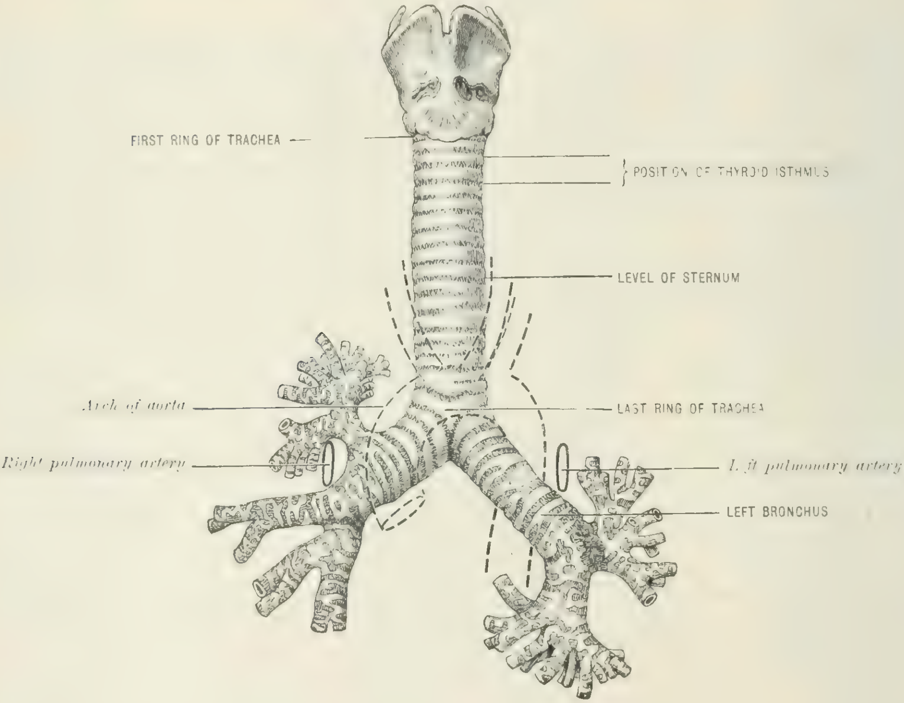
The **first cartilage** is broad, and is occasionally united with the cricoid above, or second ring of the trachea below.

The **last cartilage** is likewise broad and strong, and sends a curved beak downwards and backwards at the point of bifurcation of the trachea. It forms an imperfect ring on each side above the commencement of the corresponding bronchus.

Two cartilages not uncommonly unite in part, and thus present a bifurcated appearance.

The **fibres of the trachealis** are unstriped, and form a transverse layer at the posterior flattened part of the tube, with an indistinct layer of longitudinal fibres superimposed.

Fig. 536.—Anterior View of the Larynx, with the Trachea and Bronchi. (Modified from Bourgery.)



The **yellow elastic fibres,** which exist throughout the entire mucous membrane, form a definite and deep layer at the posterior flattened portion of the tube. They are gathered into strong longitudinal flattened bands, especially well seen at the lower part of the trachea, and where the fibres separate to pass into the bronchi.

The **mucous membrane** is smooth and pinkish in colour; it is provided with numerous glands, especially at its hinder part, and is lined by a columnar ciliated epithelium.

The **arteries** are derived from the inferior thyroid.

The **veins** join the thyroid plexuses; and the **nerves** are supplied by branches from the pneumogastric, the recurrent laryngeal, and sympathetic.

THE BRONCHI

The **right bronchus** (fig. 536), from its commencement to the origin of its first branch, is about one inch in length (25 mm.). It is shorter and wider than the left, and in direction more horizontal in its passage to the root of the lung.

Relations.—The vena azygos major arches above it from behind to end in the superior vena cava, which latter is placed anteriorly. The right pulmonary artery is at first below, and then in front of it.

The **left bronchus** is about two inches in length (50 mm.) outside of the lung. It is more oblique, longer, and narrower than the right.

Relations.—It lies beneath the arch of the aorta, and rests upon the œsophagus and the descending aorta. The left pulmonary artery lies in front of it. On looking down the trachea the dividing ridge between the two bronchial orifices is seen to be on the left of the middle line, more of the right orifice for this reason being visible. This explains the fact that foreign bodies entering the trachea most commonly become lodged in the right bronchus.

Above the point where it is crossed by the pulmonary artery the right bronchus gives off an eparterial branch to the upper lobe of the right lung. Below the points where they are crossed by the pulmonary arteries, in the substance of the lungs, both bronchi give off two series of hyparterial branches, lateral and dorsal, which rise alternately. The dorsal branches pass towards the posterior borders of the lungs, and the lateral branches curve outwards and forwards towards the anterior borders. The first lateral branch on the right side supplies the middle lobe, and the first lateral branch on the left side the upper lobe, all the remaining hyparterial branches are distributed to the lower lobe. In addition to the two main sets of hyparterial branches a number of small accessory bronchi arise from the antero-lateral aspect of each stem bronchus; of these one which rises on the right side a short distance below the level of the first dorsal bronchus is called the cardiac bronchus, because in some mammals it supplies a special lobe of the right lung which lies below and posterior to the heart. This small bronchus is the fourth branch from the right stem bronchus.

As the pulmonary artery passes downwards in the lung it lies on the postero-external aspect of the stem bronchus between the lateral and dorsal branches, and the pulmonary vein is situated on the opposite side of the tube.

THE THYROID BODY OR GLAND

The **thyroid body** is of a reddish colour, and is classed amongst the ductless glands. It consists of two **lateral lobes**, and a connecting **isthmus** which unites them below.

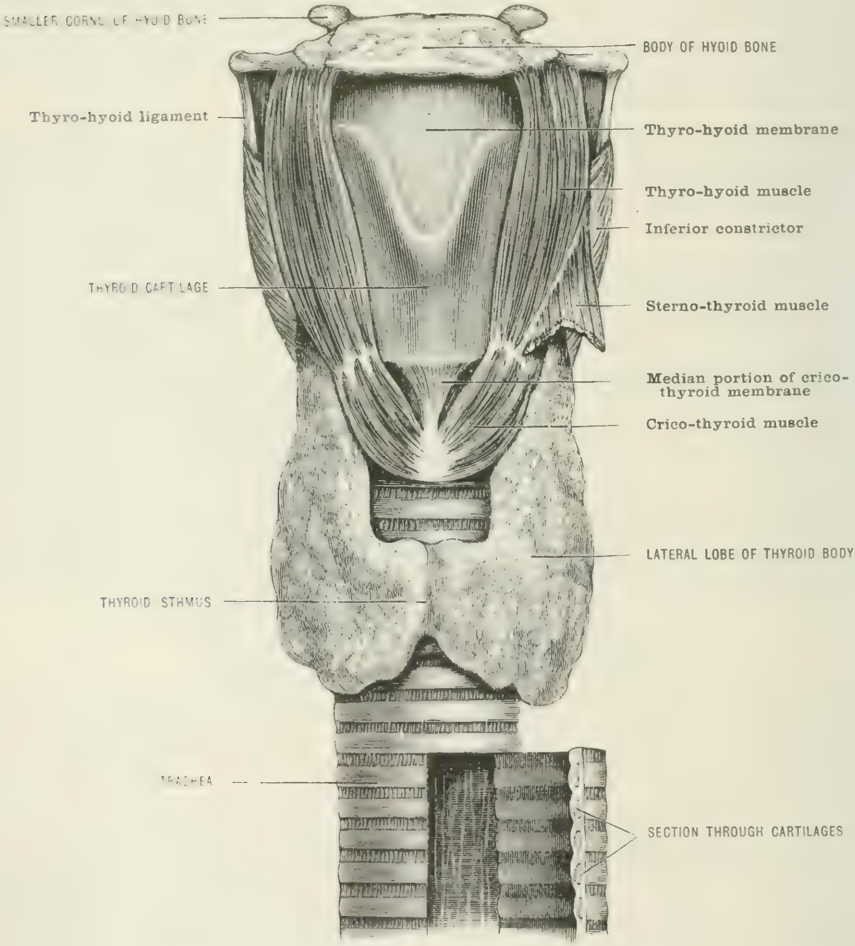
The gland is convex and rounded on its outer surface, but deeply it is moulded to the parts which it overlies. It commonly weighs from one to two ounces, but is larger in the female, and is often increased in size during menstruation.

The lateral lobes are pyriform in shape, with their broad ends below, and measures about two inches (50 mm.) in length, three-quarters of an inch (18 mm.) in breadth, and about an inch (25 mm.) in thickness near the middle.

Relations of the lateral lobes.—The apex lies between the sterno-thyroid and the inferior constrictor of the pharynx, the latter separating it from the hinder part of the ala of the thyroid cartilage and its inferior cornu. The base is rounded; it lies under cover of the sterno-thyroid and sterno-hyoid muscles at the level of the sixth ring of the trachea and about three-quarters of an inch (18 mm.) above the sternum. Some large radicles of the inferior thyroid vein issue from it. The external surface is convex, it is covered by the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles, and it is overlapped by the anterior part of the sterno-mastoid. The internal surface is concave; it is moulded on the trachea. The posterior border is thick, it is in contact with the carotid sheath, and is grooved by the common carotid artery; on the left side, it lies in front of the œsophagus, and on both sides in front of the recurrent laryngeal nerve and the inferior thyroid artery. The anterior border is thin, above it is in relation with the internal terminal branch of the inferior thyroid artery, and in the lower part of its extent it is united to its fellow of the opposite side by the isthmus.

Relations of the Isthmus.—The isthmus varies in breadth from a quarter to three-quarters of an inch (6 to 18 mm.). Its anterior surface is convex and it lies in relation with the deep fascia, anterior jugular veins, superficial fascia and skin. Its posterior concave surface rests upon the second, third, and fourth rings of the trachea. Its extremities are connected with the lower parts of the inner borders of the lateral lobes. Its lower border gives exit to some tributaries of the inferior thyroid veins and its upper border is in relation with the anastomosis between the internal terminal branches of the superior thyroid arteries, frequently a pyramidal process springs from it, and the levator glandulæ thyroideа, if present, is attached to it.

Fig. 537.—View of Thyroid Body.


SMALLER CORNU OF HYOID BONE
BODY OF HYOID BONE
Thyro-hyoid ligament
Thyro-hyoid membrane
Thyro-hyoid muscle
Inferior constrictor
THYROID CARTILAGE
Sterno-thyroid muscle
Median portion of crico-thyroid membrane
Crico-thyroid muscle
LATERAL LOBE OF THYROID BODY
THYROID ISTHMUS
TRACHEA
SECTION THROUGH CARTILAGES

The pyramidal process is variable; when present it is attached by its base to the upper border of the isthmus or to the adjacent part of the left lateral lobe. It is the remains of a duct, the thyro-glossal duct, which extends in the fœtus from the foramen cæcum of the tongue, behind the hyoid bone, to the isthmus of the thyroid body, which is developed from its lower extremity.

The **capsule** and **suspensory ligaments.**—A fibrous capsule of deep cervical fascia completely encloses the thyroid body and sends septa inwards between its lobes. The superficial vessels ramify beneath it and from its inner and back part two broad bands, the suspensory ligaments, pass upwards to the cricoid cartilage.

Structure.—The thyroid body, enveloped in a dense but thin covering of areolar tissue, is made up of a number of closed follicles. These are surrounded by an open vascular meshwork supported by the interstitial connective tissue. The follicles are grouped into irregular lobules, and these form in turn the lobes of the

Fig. 538.—Thyroid Body, with Middle Lobe and Levator Muscle.

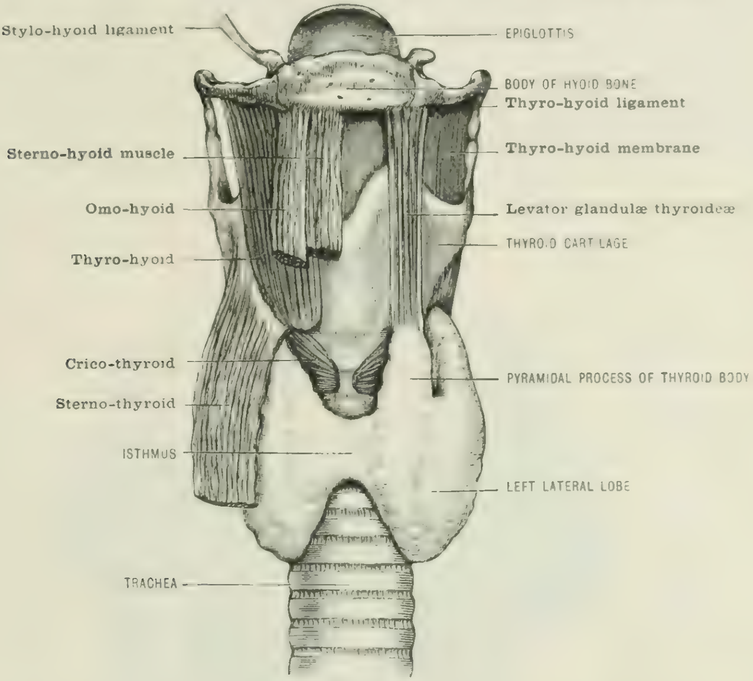
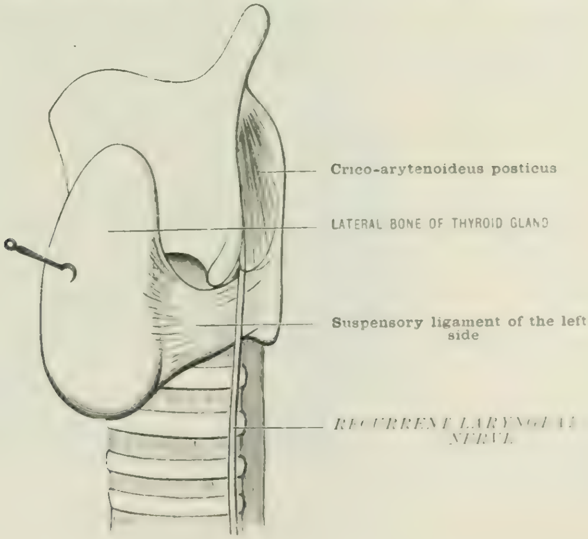

Stylo-hyoid ligament
EPIGLOTTIS
BODY OF HYOID BONE
Thyro-hyoid ligament
Sterno-hyoid muscle
Thyro-hyoid membrane
Omo-hyoid
Levator glandulæ thyroideæ
THYROID CARTILAGE
Thyro-hyoid
Crico-thyroid
PYRAMIDAL PROCESS OF THYROID BODY
Sterno-thyroid
ISTHMUS
LEFT LATERAL LOBE
TRACHEA

Fig. 539.—The Suspensory Ligaments of the Thyroid Body. (After Berry


Crico-arytenoideus posticus
LATERAL BONE OF THYROID GLAND
Suspensory ligament of the left side
RECURRENT LARYNGEAL NERVE

gland. Both the interior of the follicles and the spaces in the connecting areolar tissue may become filled with colloid material.

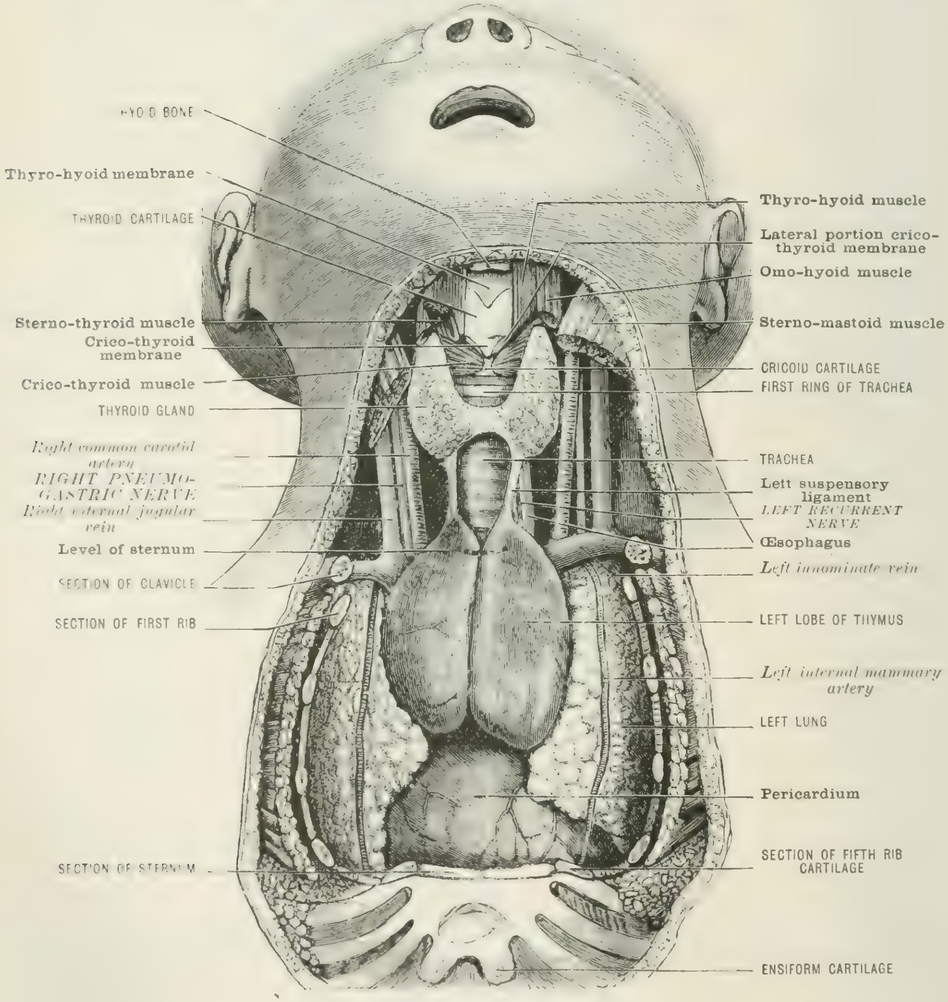
Vessels.—The **arteries**—which are relatively very large and frequently anastomose—are the two superior thyroids, the two inferior thyroids, and an occasional branch which ascends on the front of the trachea, the thyroidea ima. This latter is derived either from the innominate artery or from the arch of the aorta.

The superior thyroid arteries descend to supply the apices and inner and fore parts of the lateral lobes; whilst the inferior ascend to supply their outer and hinder portions below.

The **veins** are the superior middle and the inferior thyroid. The two former join the internal jugular vein, and the latter the innominate of the corresponding side.

The **nerves** are derived from the middle cervical ganglion of the sympathetic.

FIG. 540.—THYMUS GLAND IN A CHILD AT BIRTH.


HYOID BONE
Thyro-hyoid membrane
THYROID CARTILAGE
Sterno-thyroid muscle
Crico-thyroid membrane
Crico-thyroid muscle
THYROID GLAND
Right common carotid artery
RIGHT PNEUMOGASTRIC NERVE
Right external jugular vein
Level of sternum
SECTION OF CLAVICLE
SECTION OF FIRST RIB
SECTION OF STERNUM
Thyro-hyoid muscle
Lateral portion crico-thyroid membrane
Omo-hyoid muscle
Sterno-mastoid muscle
CRICOID CARTILAGE
FIRST RING OF TRACHEA
TRACHEA
Left suspensory ligament
LEFT RECURRENT NERVE
Œsophagus
Left innominate vein
LEFT LOBE OF THYMUS
Left internal mammary artery
LEFT LUNG
Pericardium
SECTION OF FIFTH RIB CARTILAGE
ENSIFORM CARTILAGE

THE THYMUS BODY OR GLAND

The **thymus body**, like the thyroid, is ductless. It reaches its highest development about the end of the second year. Although it occasionally retains a considerable size in the adult, it usually disappears or shrivels away to an insignificant vestige.

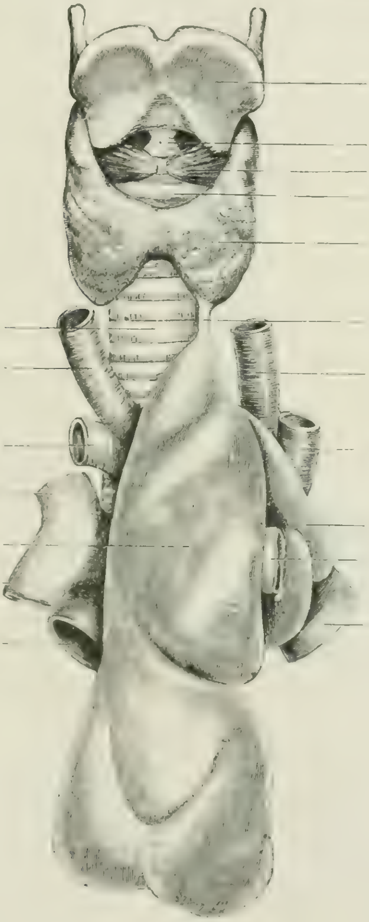
It is commonly made up of two elongated, nearly equal pyramidal lobes of a greyish pink colour, which meet each other near the middle line; but they vary in number and are inconstant in size. There may be but a single lobe present, or a third may intervene between the other two. Sometimes the right lobe and sometimes the left lobe is the larger.

The thymus body is about two inches (50 mm.) in length, about one inch and a half (37 mm.) in breadth at its base, and a quarter of an inch (16 mm.) in thickness.

Its weight at birth is about half an ounce.

Relations.—The thymus body at the period of its fullest development lies partly in the thorax and partly in the neck. It extends upwards as far as the thyroid body covered by the sterno-hyoid and thyroid muscles, completely hiding the trachea and the carotid sheaths. Below, it descends into the superior mediastinum between the pleural sacs and internal mammary vessels as far as the fourth rib cartilages, and lies behind the sternum, the sterno-hyoid, and sterno-thyroid muscles, and in front of the pericardium and larger vessels.

Fig. 541.—Thymus Gland in a Child at the Age of Two Years.


THYROID CARTILAGE
Central portion of crico-thyroid membrane
Crico-thyroid muscle
FIRST RING OF TRACHEA
THYROID BODY
Ligament connecting thyroid and thymus bodies
SEVENTH RING OF TRACHEA
Right carotid artery
Left carotid artery
Right subclavian artery
Left subclavian artery
Right innominate vein
LOBE OF THYMUS PASSING BEHIND VEIN
THYMUS GLAND
Left innominate vein
Vena cava superior
Arch of aorta
Arch of aorta

Structure.—A thin areolar capsule invests the lobes of the thymus gland, and extends upwards in the form of two flattened fibrous bands to be attached to each lobe of the thyroid body. These bands are well marked at the period of birth, and seem to act as suspensory ligaments. If the capsule is removed, it is seen to send inwards numerous prolongations from its deep surface, which pass between the lobules to surround and connect them.

The lobules are irregular and many-sided, and consist of numerous lymph follicles. They are grouped around a central tubular cord of connective tissue, and when unravelled the lobe can be lengthened out, the lobules then appearing to be attached to the cord in a spiral fashion.

The vessels.—The **arteries** are derived from the internal mammary and from the superior and inferior thyroids.

The **veins** join the left innominate and thyroid veins.

The **nerves** are very minute, and proceed from the sympathetic and pneumogastric.

THE ORGANS OF RESPIRATION

THE LUNGS AND PLEURÆ

The **lungs**—which are two in number—are the special organs of respiration, and occupy the greater portion of the chest cavity. They are separated one from the other by the heart and great vessels, and the other contents of the mediastinal spaces, and each is enclosed in a pleural sac.

THE PLEURÆ

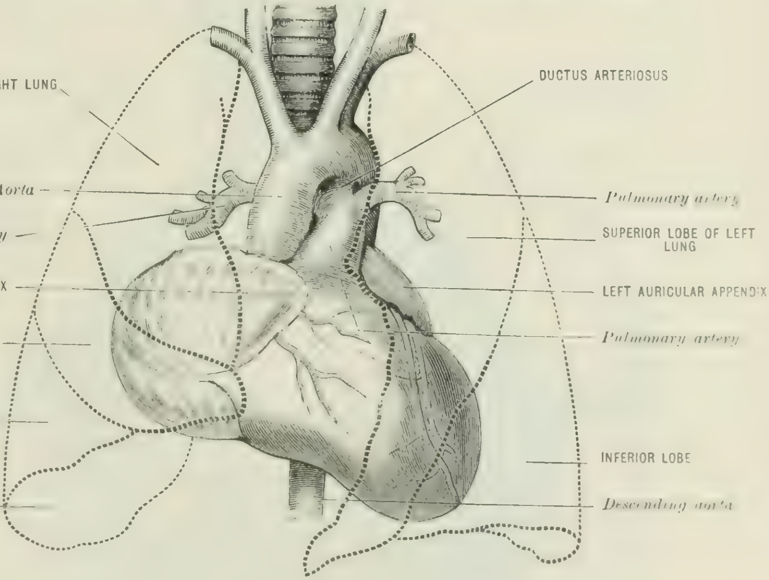
Each lung is closely invested by an invaginated serous sac, the pleural sac. The inner wall of the sac, which is closely attached to the lung substance and surrounds its root, is the visceral pleura. The outer wall of the sac is the parietal pleura, and the two parts are directly continuous at the root of the lung. The parietal pleura covers the inner surface of the thoracic wall, and it forms the lateral boundary of the mediastinal space of the thorax. Under ordinary circumstances the inner surface of the parietal pleura is in contact with the outer surface of the visceral pleura, or at the most only a thin layer of serous fluid intervenes, and both surfaces are smooth and glistening; but if the pleural sac is opened the lung shrinks, on account of its elasticity, and a space, the pleural cavity, is developed between the two layers.

For convenience of description the parietal pleura may be divided into three parts—the external or costal, the inferior or diaphragmatic, and the internal or mediastinal. The costal portion of the parietal pleura is in relation with the ribs, the costal cartilages, the contents of the intercostal spaces, the triangularis sterni, and the subcostal muscles, to which it is attached by the endothoracic fascia. The diaphragmatic portion rests upon the diaphragm, and the mediastinal part is in relation with the contents of the mediastinal space—that is, on both sides, with the pericardium, the phrenic nerve and its accompanying vessels, on the right side in addition with the ascending aorta, the superior vena cava, the vena azygos major, the right innominate vein, the innominate artery and the right vagus nerve; and on the left side the additional relations are the transverse and descending portions of the aorta, the left common carotid and subclavian arteries, the thoracic duct, the left superior intercostal vein and the left vagus nerve.

The upper extremity of each pleural sac extends into the neck, reaching a point an inch (25 mm.) to an inch and a half (37 mm.) above the clavicle, but never above the neck of the first rib; it is covered by a layer of fascia called Sibson's fascia; it is in relation with the subclavian artery, which lies in a groove on its antero-internal aspect, and with the scalenus medius and anticus muscles.

The borders of each pleural sac are anterior, inferior and posterior. On the right side the anterior border passes obliquely downwards from the apex, behind the sterno-clavicular articulation, to the middle line, at the junction of the manubrium with the body of the sternum (fig. 521), thence it descends vertically to the lower end of the gladiolus. The lower border extends round the base of the sac, commencing at the lower end of the gladiolus it runs downwards and outwards behind the seventh costal cartilage, still descending it crosses the seventh, eighth, and ninth ribs reaching the lower border of the latter in the mid-axillary line; passing backwards it comes into relation with the tenth, eleventh, and twelfth ribs, and ascending to the head of the latter it joins the posterior border, and then, turning forwards, it passes along the groove between the pericardium and the diaphragm to its point of commencement. The posterior border extends from the neck of the first rib to the head of the twelfth; it is broad and rounded. The anterior border on the left side descends inwards behind the sterno-clavicular articulation as on the right side, and reaches the middle line at the same point, then it passes vertically downwards to the level of the fifth chondro-sternal articulation (fig. 521), from this point it runs downwards and outwards behind the cartilages of the fifth and sixth ribs to the seventh costo-chondral joint, where it joins the inferior border. The inferior border descends across the eighth, nine, and tenth ribs to the lower border of the latter in the mid-axillary line, further back it crosses the eleventh rib and ascends along the twelfth rib to join the posterior border, as on the right side. The general relations of the inner part of the lower border and the whole of the posterior border are the same as on the right side.

Fig. 542.—Anterior View of Fœtal Heart, Vessels, and Lungs.



The lower extremity of the pleural sac does not extend to the lower extremity of the thorax, laterally; therefore for a short distance the diaphragm and the lowest intercostal muscles are in contact.

Below the root of each lung a fold of the pleura descends to the diaphragm, the **ligamentum latum pulmonis.** The pleural sacs on each side pass for an inch or more above the level of the anterior part of the first rib, beneath the scalene muscles, covering the apices of the lungs, and the parietal layer is here strengthened by a dome of fascia which descends from beneath the muscles to the inner border of the first rib. The interval between the two sacs is considerable both above and below; but opposite the second piece of the sternum, corresponding with the second, third, and fourth rib cartilages (fig. 521), they are closely approximated or in actual contact.

The lungs are not quite so extensive as the pleural sacs, and this is more especially the case in the regions of the inferior, and the lower parts of the anterior borders where two layers of parietal pleura are in contact with each other, these regions are known as the pleural sinuses, and they vary in extent with the distension of the lungs.

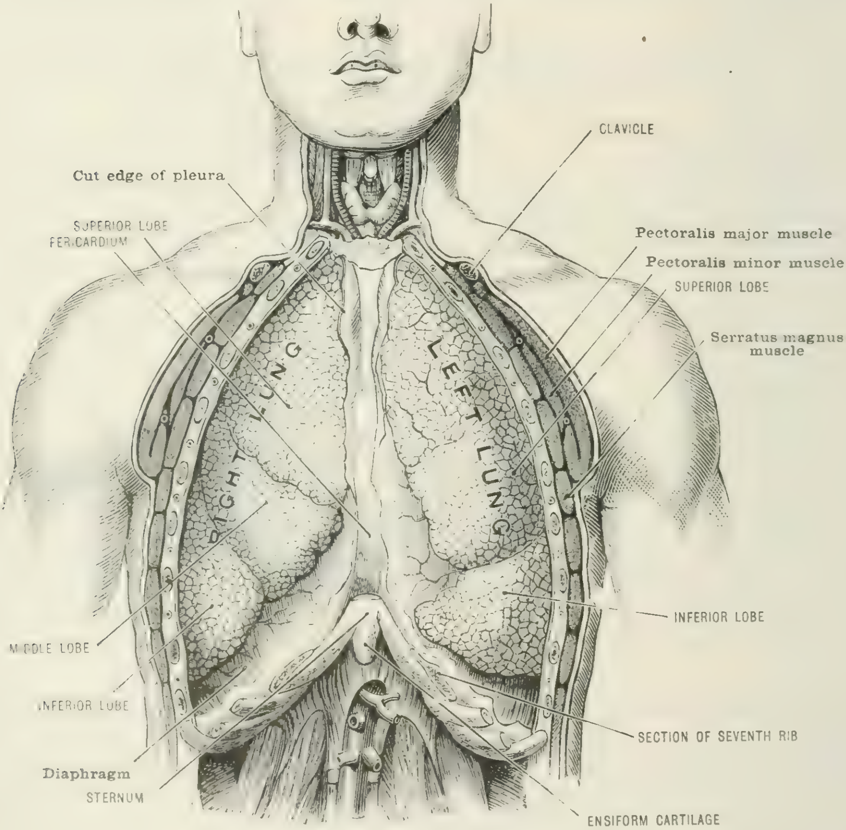
The **right pleural sac**, though shorter and wider than the left, reaches as a rule somewhat higher in the neck.

The Lungs.—Each lung presents an outer and an inner surface, separated by an anterior and a posterior border, with a base and an apex.

The **outer surface** is convex, and mainly corresponds to the concavity of the inner surface of the lateral wall of the thorax.

The **inner surface** is concave, and comes into contact with the pericardium and lateral pleural wall of the mediastinal spaces.

Fig. 543.—Anterior View of the Thorax with Chest Wall removed, showing the Lungs. (Modified from Bourgery.)


CLAVICLE
Cut edge of pleura
SUPERIOR LOBE
PERICARDIUM
Pectoralis major muscle
Pectoralis minor muscle
SUPERIOR LOBE
Serratus magnus muscle
RIGHT LUNG
LEFT LUNG
INFERIOR LOBE
MIDDLE LOBE
INFERIOR LOBE
SECTION OF SEVENTH RIB
Diaphragm
STERNUM
ENSIFORM CARTILAGE

The **posterior border** is the longer; it is thick, rounded, and smooth, and occupies the groove on the side of the vertebral column.

The **anterior border** is thin, irregular, and sharply edged, and is deeply notched in the left lung leaving the pericardium uncovered.

The **base** is concave, and rests on the corresponding arch of the diaphragm; whilst the **apex** passes above the anterior part of the first rib to lie beneath the subclavian artery. Each lung is divided into **two lobes** by a deep fissure which passes obliquely upwards and inwards almost to the root of the organ. This fissure commences at the posterior border, about 7·5 cm. below the apex, and, sweeping round the convex surface of the lung, ends near the anterior border below.

In the right lung a second fissure passes from the anterior edge to reach the main fissure near its centre, marking off a **third** or **middle lobe.**

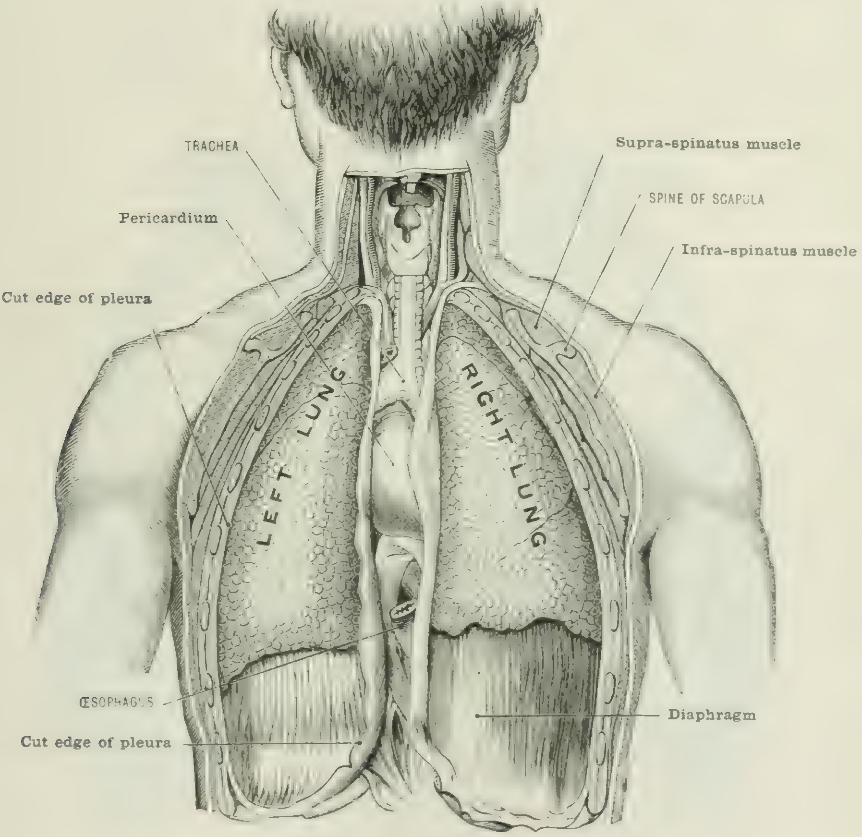
The **right lung** is somewhat larger than the left; it is also shorter, and, as just mentioned, possesses three lobes.

Above the middle of the inner aspect, but nearer to the posterior than the anterior border, each lung is connected to the pulmonary vessels and bronchi which form the main part of its root.

The **root of the lung** is composed of the **pulmonary artery** and the **pulmonary veins** with the corresponding **bronchial tube**; and, in addition, the **bronchial vessels**, the branches of the **anterior** and **posterior pulmonary plexuses** with some **bronchial lymphatic glands** and **areolar tissue**—the whole being encased in a **pleural covering.**

The **right root** lies behind the superior cava and upper portion of the right auricle of the heart, the anterior pulmonary plexus and the phrenic nerve; above, the vena azygos major arches to join the superior cava; behind is the posterior pulmonary plexus, the pneumogastric nerve, and the vena azygos major; whilst below is the ligamentum latum pulmonis.

Fig. 544.—Posterior View of the Thorax with Chest Wall Removed, showing the Lungs. (Modified from Bourgery.)



The **left root** has the pulmonary plexus and left phrenic in front; above it is the arch of the aorta; behind, the descending aorta and pneumogastric nerve with the posterior pulmonary plexus; whilst below stretches downwards the ligamentum latum pulmonis.

The chief structures contained within the root vary in position on the two sides. **From above downwards** on the **right side,** they lie as follows—bronchus, artery, and upper vein; whilst on the **left side** the artery is the highest, the bronchus is placed next, and the upper vein is again the lowest. **From before backwards** on both sides, the arrangement is—upper vein, artery, and bronchus.

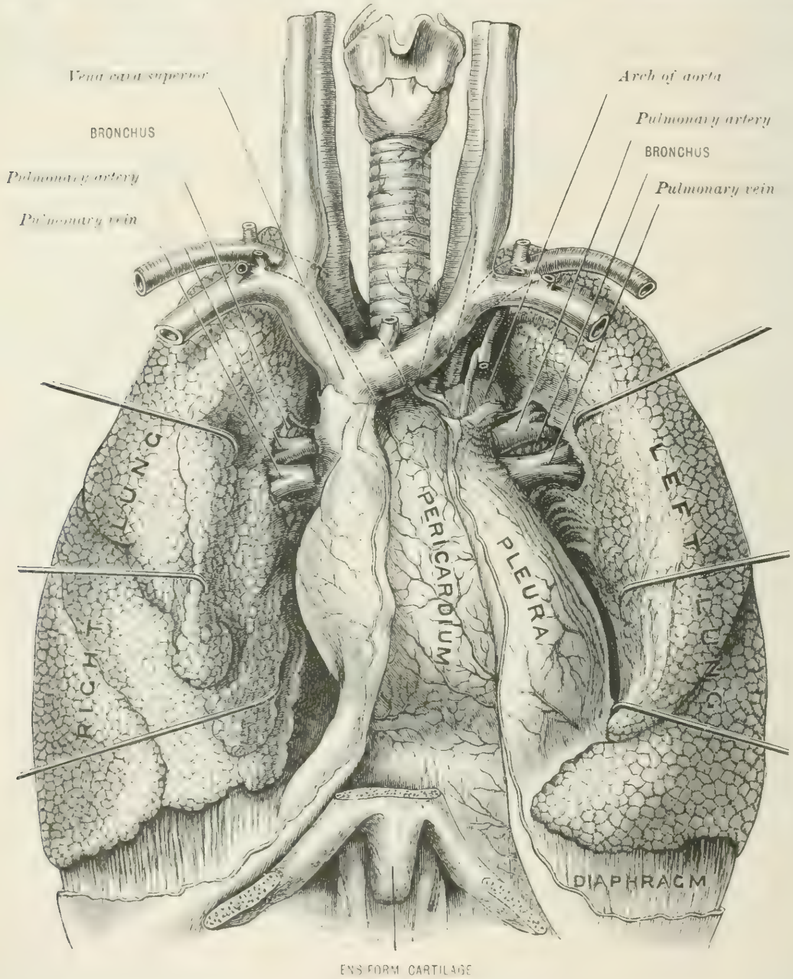
The **weight of the lungs** together is about forty-two ounces; the right lung is about two ounces heavier than the left.

In color the lungs are of a pinkish white; but they become darker, mottled, and even black, as age advances.

Structure.—The lungs possess an external **serous coat** derived from the pleura, beneath which is a delicate **subserous layer.**

The **parenchyma,** or lung substance, is composed of **minute lobules** connected by interlobular areolar tissue. Each lobule is made up of a ramification of a **bronchial tube** with its cluster of **terminal air cells,** with a minute plexus of **pulmonary** and **bronchial vessels, nerves,** and **lymphatics.**

Fig. 545.—Anterior View of the Lungs: Pericardium. (Modified from Bourgery.)


Vena cava superior
BRONCHUS
Pulmonary artery
Pulmonary vein
Arch of aorta
Pulmonary artery
BRONCHUS
Pulmonary vein
RIGHT LUNG
PERICARDIUM
PLEURA
LEFT LUNG
DIAPHRAGM
ENSIFORM CARTILAGE

The vessels.—The **pulmonary arteries** convey venous blood from the heart to the lungs; they divide into branches which follow the bronchial tubes, and finally terminate in a flat meshwork upon the walls of the intercellular passages and air cells.

The **radicles of the pulmonary veins** start from this network; they coalesce into larger branches which accompany the arteries and terminate in two large vessels on each side, which return the **arterial blood** to the left auricle of the heart.

The **bronchial arteries**, one on the right side, and two on the left, are the nutrient vessels of the lungs. The right springs from the first aortic intercostal artery or from the upper left bronchial artery. The two left bronchial arteries are branches of the descending thoracic aorta. Some of their branches ramify in an open plexus outside the lung beneath the pleura; another set supply the interlobular areolar tissue; whilst a third set of branches supply the bronchial tubes with their lining membrane and muscular walls, the walls of the vessels, and the bronchial glands. The ramifications of this set reach and mingle with the pulmonary vessels, and thus a small quantity of the blood conveyed by the bronchial arteries is returned as arterial through the pulmonary veins to the heart.

The **bronchial veins** consist of a **superficial** and a **deep set**, which join, to form a single vessel on each side; the right bronchial vein opens into the vena azygos major, and the left into the left superior intercostal vein.

The **lymphatics** form a superficial and a deep set.

The **nerves** are derived from the anterior and posterior pulmonary plexuses.

THE ORGANS OF CIRCULATION

THE PERICARDIUM

The **pericardium** is a cone-shaped, fibro-serous sac surrounding the heart, with its apex above, and its base below and adherent to the diaphragm. The **fibrous layer** is very strong and inelastic, and is composed of interlacing fibres. Below, its connection with the central tendon of the diaphragm is close and intimate. It is very firmly bound to the caval opening, but loosely attached and easily separable elsewhere. Above, it is lost on the sheaths of the great vessels, all of which receive distinct investments, with the single exception of the inferior vena cava, which pierces it from below.

The aorta, superior vena cava, both divisions of the pulmonary artery, with the **ductus arteriosus**, together with the four pulmonary veins, are all ensheathed in this manner. The fibrous portion of the pericardium, through the sheaths prolonged over the great vessels, ultimately becomes continuous above with the deep cervical fascia. Two slight bands of fibrous tissue—the **sterno-pericardial bands** or ligaments—connect the front of the pericardium, above and below, with the posterior surface of the sternum.

The **serous layer** is smooth and glistening. Its **parietal portion** lines the inner surface of the fibrous bag. The **visceral portion** is reflected over the surface of the heart and the roots of the great vessels, the two layers being in close contact, and moistened with a thin secretion to allow the free movement of the heart. A series of pouches or sinuses are thus formed at the line of reflexion. Between the inferior vena cava and lower left pulmonary vein, the **oblique sinus** ascends behind the left auricle, partially investing the pulmonary arteries and the pulmonary veins of the right and left sides, between which it passes. Small pouches from the main sac dip between the veins to meet the inflexions from the sides of the oblique sinus just noticed, thus completing the serous coverings to these vessels.

Pouches can be further traced between the inferior vena cava and lower pulmonary vein of the right side, between the superior vena cava and upper pulmonary vein of the same side, and also between the left pulmonary artery and left upper pulmonary vein.

A tubular prolongation, moreover, surrounds both the root of the pulmonary artery and the aorta in common, and these are the only vessels which can be said to have a complete and continuous investment.

There is, therefore, a communication behind them between the right and left sides of the pericardial sac; this is the great sinus of the pericardium. The inferior vena cava receives a very imperfect covering.

The **vestigial fold of the pericardium** is a doubling of the serous layer which passes between the left pulmonary artery above and left superior pulmonary vein below. It contains, besides some fatty and areolar tissue, the shrunken remains of the left superior vena cava. It is connected above with the left superior intercostal vein, and below with the left auricle and **oblique vein of Marshall,**—these veins with the coronary sinus having originally formed portions of the left upper cava.

Relations.—In front are found the thymus gland or its remains, areolar tissue, the sterno-pericardiac ligaments, the left triangularis sterni muscle, the internal mammary vessels, the anterior margins of the pleural sacs and lungs, and the sternum. Laterally, it is overlapped by the lungs with their pleural sacs, and it is in relation with the phrenic nerves and their accompanying vessels. Posteriorly, it is in relation with the oesophagus, and pneumogastric nerves, the descending aorta, the thoracic duct, and vena azygos major.

On opening the pericardium the following structures may be observed: the greater part of the **right** and a portion of the **left ventricle** with the interventricular sulcus, the **right auricle** and **right auricular appendix** (the latter overlapping the root of the aorta), the auriculo-ventricular sulcus; the first portion of the **aorta** with the **superior vena cava** on its right side, and the **pulmonary artery** at first overlying and then passing to its left side, with the tip of the **left auricular appendix.** If the heart be raised upwards and to the right, its posterior surface is seen to consist of the greater part of the **left ventricle,** and the remaining portion of the right, the interventricular sulcus dividing the two. Lying transversely above the ventricle in the auriculo-ventricular groove is the **coronary sinus,** receiving some of the **cardiac veins,** and also the **oblique vein of Marshall** from the back of the left auricle, the roots of the **pulmonary veins,** and the very small portion of the **inferior cava** above the diaphragm, may also be noticed.

The two ventricles rest in about equal proportions on the central tendon of the diaphragm. The main branches of the **coronary arteries** of the heart occupy the grooves.

Vessels.—The arteries of the pericardium are derived from the pericardiac, oesophageal, and bronchial branches of the thoracic aorta and from the internal mammary and phrenic arteries.

THE HEART

The **heart**—enclosed in the pericardium—occupies the greater part of the middle mediastinal space. It is a somewhat flattened, cone-shaped, hollow, muscular organ.

Position.—In the adult the heart lies obliquely behind the lower two-thirds of the sternum, projecting considerably to its left side. Its **base** is directed slightly upwards and backwards, and to the right; its **apex** downwards and forwards, and to the left. The **base** corresponds to the sixth, seventh, and eighth thoracic vertebrae; and the **apex** to the chest wall on the left side, between the fifth and sixth rib cartilages.

It may be mapped out on the chest wall in the following manner: a line drawn across the sternum about the level of the lower borders of the second costal cartilages, passing half an inch to the right and one inch to the left of the sternum, will indicate the position of its **base,** from which the great vessels arise.

The **apex,** as before observed, strikes the chest wall between the fifth and sixth rib cartilages on the left side, at a spot about a couple of inches (50 mm.) below the nipple, and one inch (25 mm.) to its sternal side, or three and a quarter inches (81 mm.) from the middle line of the sternum, in the fifth interspace.

The **lower border** is formed by the right ventricle and rests on the central tendon of the diaphragm. It is defined by a line curving downwards, commencing at the apex, and crossing close to the sterno-xiphoid articulation and terminating at the right edge of the sternum near its junction with the sixth cartilage.

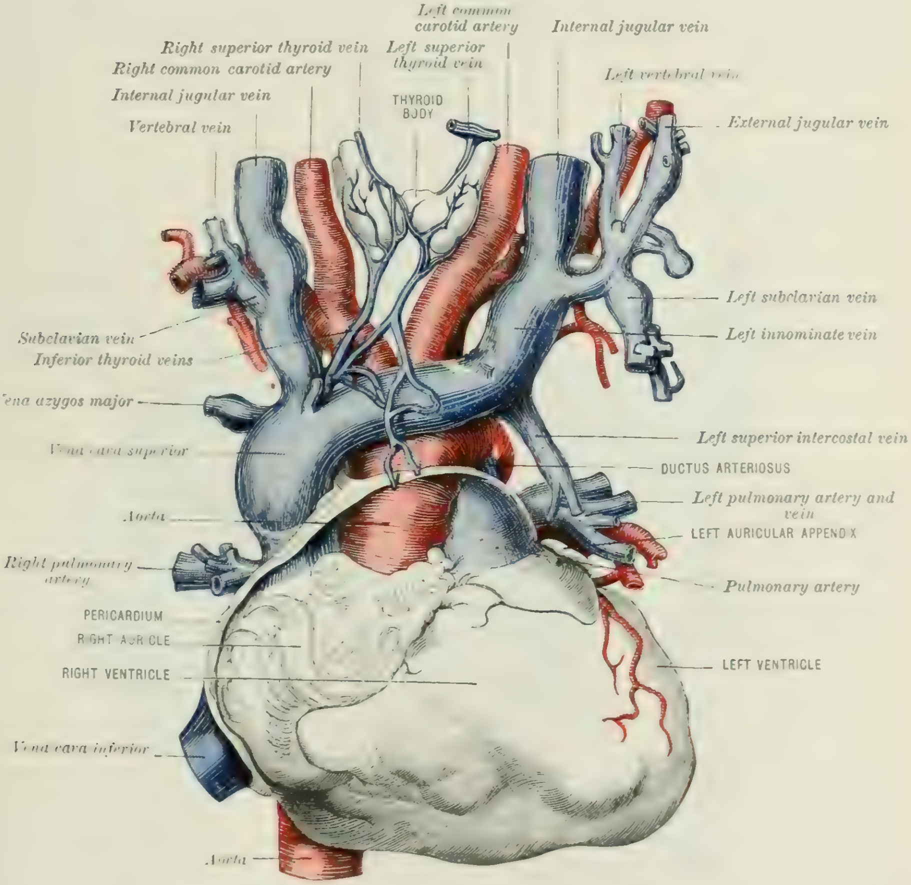
The **lateral borders** may be completed by drawing curved lines upwards from the points last named to the ends of the basal line. The right border consists entirely of the right auricle, and the left of the left ventricle.

The position of the auriculo-ventricular sulcus is indicated by a line from the third left costal cartilage to the sixth right.

Size and weight.—In the adult the heart measures about five inches (125 mm.) from base to apex, three and a half inches (87 mm.) across where it is broadest, and two and a half (62 mm.) at its thickest portion. In the male its weight averages about eleven ounces, and in the female about nine ounces. It increases both in size and weight up to advanced life, the increase being most marked up to the age of twenty-nine years.

FIG. 546.—ANTERIOR VIEW OF THE HEART WITH THE LARGER VESSELS.

(By permission. Museum of the Royal College of Surgeons.)


Left common carotid artery
Internal jugular vein
Right superior thyroid vein
Left superior thyroid vein
Right common carotid artery
Left vertebral vein
Internal jugular vein
THYROID BODY
Vertebral vein
External jugular vein
Left subclavian vein
Subclavian vein
Left innominate vein
Inferior thyroid veins
Vena azygos major
Left superior intercostal vein
Vena cava superior
DUCTUS ARTERIOSUS
Left pulmonary artery and vein
Aorta
LEFT AURICULAR APPENDIX
Right pulmonary artery
Pulmonary artery
PERICARDIUM
RIGHT AURICLE
LEFT VENTRICLE
RIGHT VENTRICLE
Vena cava inferior
Aorta

The **anterior surface** of the heart is convex, and looks upwards and forwards. Its lower and **posterior surface**, which rests partly on the diaphragm, is flattened. The borders which divide the two surfaces of the heart meet near the apex; the right border is thin and rather longer than the left, whilst the latter border is thick and rounded.

The auricles are divided from the ventricles by a transverse groove, the **auriculo-ventricular**, which is interrupted in front by the origin of the pulmonary artery. The ventricles are similarly divided from each other by the **interventricular groove**, which runs obliquely on the anterior and posterior surfaces of the heart, meeting below just to the right of the apex where they are continuous.

The grooves are placed near the borders of the heart, so that the right ventricle is mainly anterior, and the left posterior.

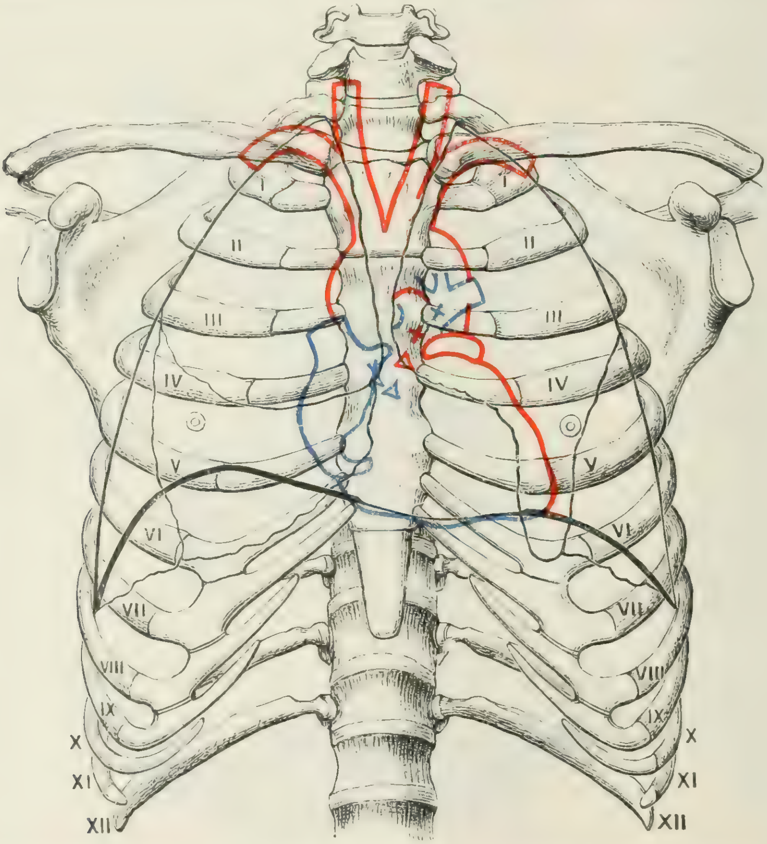
Of the **four cavities** into which the heart is divided, the right auricle and ventricle constitute its **venous side,** whilst the left auricle and ventricle belong to its **arterial side.**

The right auricle receives the venous blood of the body through the two venæ cavæ, and of the heart through the coronary sinus, and transmits it into the right ventricle. The right ventricle in turn transmits the venous blood to the lungs through the pulmonary artery. From the lungs it is returned arterialised to the left auricle of the heart by the pulmonary veins. From the auricle it passes into the corresponding ventricle, and thence through the aorta and its branches to all parts of the body, including the heart itself.

FIG. 547.—SHOWING THE POSITION OF THE HEART AND ITS VALVES IN RELATION TO THE CHEST WALLS.

(Reduced from Hensman and Fisher's Anatomical Outlines.)

(The right auricle and ventricle, with the pulmonary semilunar and tricuspid valves, are outlined in blue tints; whilst the left auricle and ventricle, with their corresponding valves, are indicated in red.)



The right auricle.—The right auricle forms the upper and right part of the heart; below it is the right ventricle; to the inner side anteriorly it embraces the root of the pulmonary artery, and posteriorly it is separated from the left auricle by the interauricular septum, and it is in relation with the right inferior pulmonary vein. It is lined by a smooth and delicate membrane, the **endocardium,** which is continuous with the inner coats of the blood-vessels. It presents a large quadrangular cavity, the **sinus venosus** or **atrium,** and one much smaller within the **auricular appendix.** The auricle forms the right and fore part of the base of the heart.

Openings.—Of the three chief openings, that of the **superior cava** appears at the upper and back part of the cavity; whilst at the lower and back part is the opening of the **inferior cava.** The right **auriculo-ventricular opening,** which leads into the ventricle, is placed below and in front; whilst above and in front the cavity is prolonged into the auricular appendix.

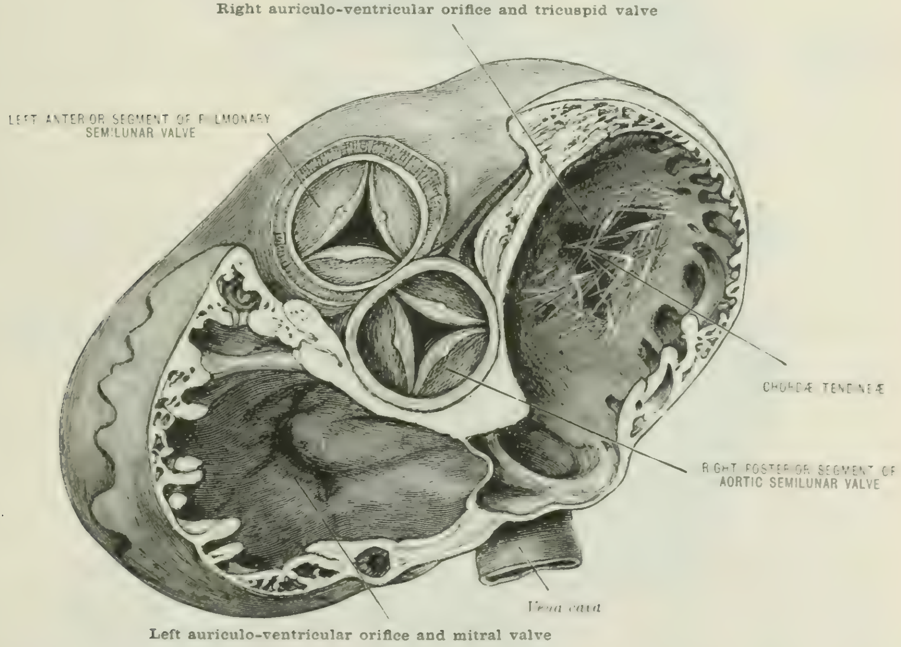
The orifice of the **coronary sinus** lies between the lower caval and auriculo-ventricular openings. Besides these there are about a score of small scattered orifices, known as the **foramina Thebesii.**

The **superior caval opening** is valveless, and is directed downwards and forwards towards the auriculo-ventricular opening.

The **inferior caval opening** is somewhat larger, and is directed upwards and inwards. It is usually guarded by a semilunar fold, the **Eustachian valve,** which is much larger in fœtal life, and which then serves to direct the current of blood through a foramen in the wall dividing the two auricles. It is attached by its convex margin to the front and left side of the vein, its free concave edge looking upwards and to the right. The left cornu or horn of the crescent is continuous with the anterior edge of the annulus ovalis, whilst the right horn is lost on the auricular wall. The Eustachian valve contains interlacing muscular fibres; it is often very incomplete and sometimes perforated.

Fig. 548.—Transverse Section passing through the Auricles of the Heart, showing the Auriculo-ventricular Orifices and the Semilunar Valves of the Pulmonary Artery and Aorta. Seen from above.

(The portions of the auricles removed are seen in Fig. 552.)


Right auriculo-ventricular orifice and tricuspid valve
LEFT ANTERIOR SEGMENT OF PULMONARY SEMILUNAR VALVE
CHORDÆ TENDINEÆ
RIGHT POSTERIOR SEGMENT OF AORTIC SEMILUNAR VALVE
Vena cava
Left auriculo-ventricular orifice and mitral valve

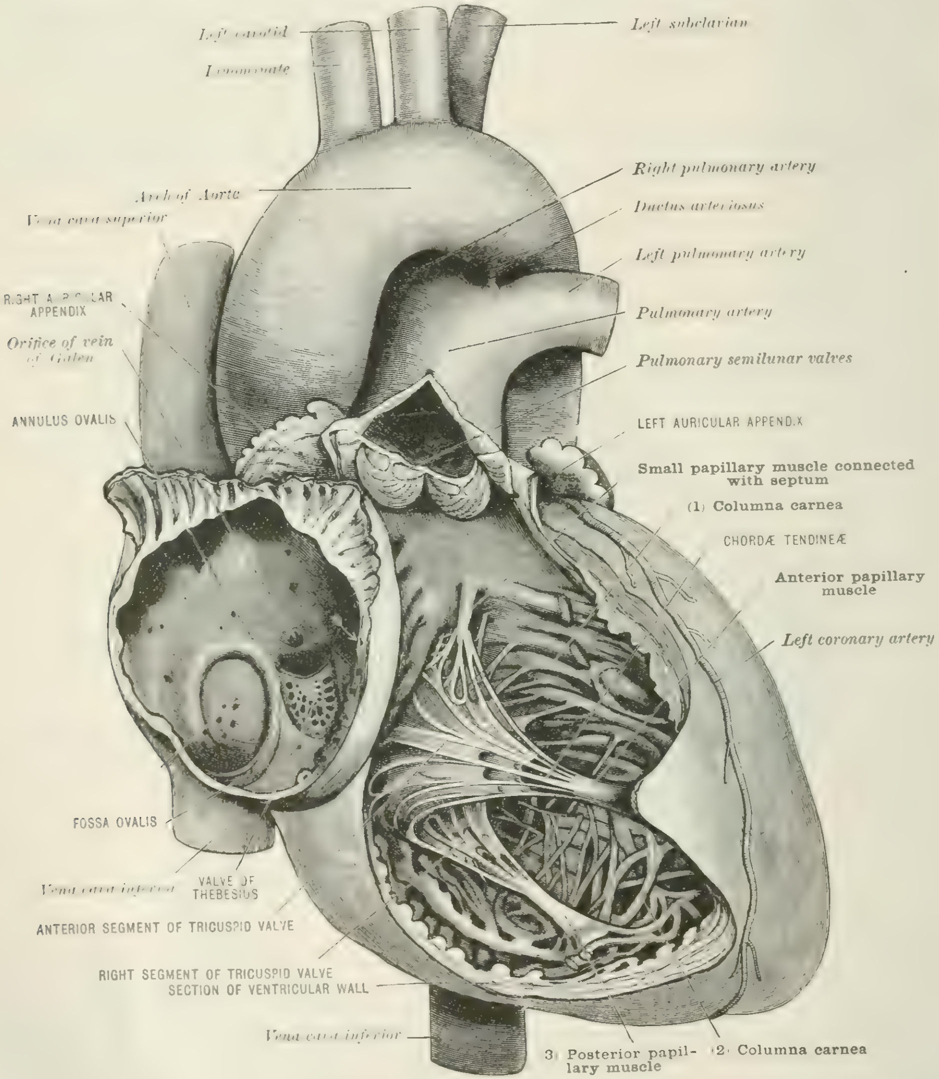
The **coronary sinus** returns the blood from the heart substance, and is guarded by a semilunar or sometimes double valve, known as the coronary valve, or **valve of Thebesius.** Like the Eustachian, it is formed of a fold of the endocardium, and serves to direct the blood current, but does not prevent regurgitation. It is sometimes perforated, and occasionally presents the most delicate lacework.

The foramina Thebesii.—The greater number of these small orifices end blindly, but the rest are the terminations of minute veins from the muscular substance (**venæ minimæ cordis**). One of these, more constant than the others, the **vena Galeni** (right marginal), usually opens below the superior cava, on the septal wall.

The **cavity of the right auricle** is smooth, except upon its anterior wall, and within the appendix, where it is ridged with muscular bands (the **musculi pectinati**), which terminate, above, along a ridge, the crista terminalis.

The crista terminalis corresponds externally with a sulcus, the sulcus terminalis, which runs across the auricle from the front of the superior cava to the left of the inferior cava, and both the groove and the ridge indicate the line of union of the sinus venosus of the fœtus with the auricle proper.

Fig. 549.—Anterior View of the Right Chambers of the Heart, with the Great Vessels.



Left carotid
Innominate
Left subclavian
Arch of Aorte
Vena cava superior
Right pulmonary artery
Ductus arteriosus
Left pulmonary artery
RIGHT AURICULAR APPENDIX
Orifice of vein of Galen
Pulmonary artery
Pulmonary semilunar valves
ANNULUS OVALIS
LEFT AURICULAR APPENDIX
Small papillary muscle connected with septum
(1) Columna carnea
CHORDÆ TENDINEÆ
Anterior papillary muscle
Left coronary artery
FOSSA OVALIS
Vena cava inferior
VALVE OF THEBESIUS
ANTERIOR SEGMENT OF TRICUSPID VALVE
RIGHT SEGMENT OF TRICUSPID VALVE
SECTION OF VENTRICULAR WALL
Vena cava inferior
(3) Posterior papillary muscle
(2) Columna carnea

At the lower part of the posterior wall or septum which divides the two auricles, and just above the orifice of the **inferior cava**, is a smooth oval depression, the **fossa ovalis**. It marks the position of the opening in the fœtal heart, to be described hereafter; and is bounded by a well-marked rounded edge, the **annulus**

ovalis. Beneath its upper margin a little valvular pouch may usually be noticed which leads into a small orifice passing into the left auricle.

The **tubercle of Lower**—which is placed on the right of the cavity between the orifices of the two cavæ—is well marked in some of the lower animals, but it is quite an insignificant eminence in man.

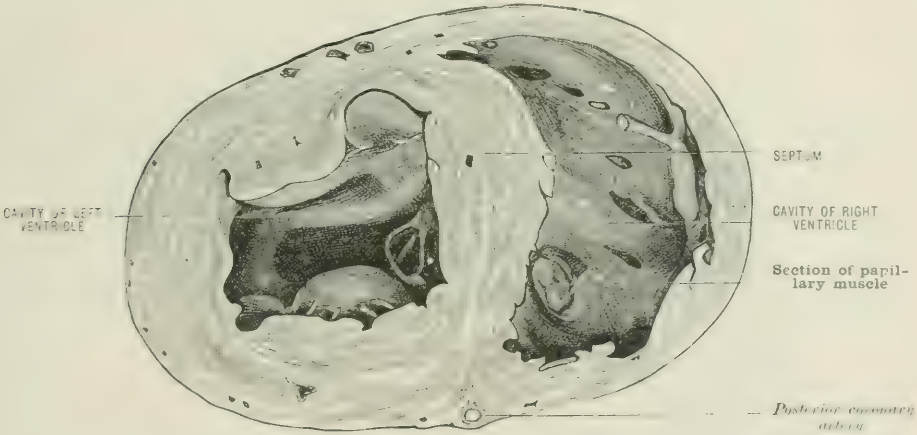
The **right ventricle** forms the larger part of the heart in front, where it is convex; but below, where it rests upon the diaphragm, it is flattened. It forms the whole of the lower border (*margo acutus*) of the heart, but it does not reach the apex, which is formed entirely by the left ventricle.

It lies behind the lower part of the body of the sternum and the cartilages of the fifth, sixth, and seventh ribs of the left side.

In form the ventricle is triangular, in section semilunar, and its walls are much thinner than those of the left ventricle. Its upper and left angle is continuous with the root of the pulmonary artery; and upon opening the cavity the two are seen to be continuous through a cone-shaped prolongation—the infundibulum or **conus arteriosus.**

At the opposite angle there is a second and larger opening, leading from the right auricle, the auriculo-ventricular orifice. It lies below and to the right of the pulmonary orifice. The apex of the ventricle points to the left.

FIG. 550.—TRANSVERSE SECTION THROUGH THE HEART NEAR ITS APEX, SHOWING THE RELATIVE THICKNESS OF ITS MUSCULAR WALLS, THE BULGING OF THE SEPTUM TOWARDS THE RIGHT VENTRICLE, AND THE SHAPE OF THE CAVITIES.


SEPTUM
CAVITY OF LEFT VENTRICLE
CAVITY OF RIGHT VENTRICLE
Section of papillary muscle
Posterior coronary artery

The two openings just named are guarded by valves and separated by a rounded muscular projection of the ventricular wall. The **inner surface,** or **body,** of the ventricle presents a somewhat complicated arrangement of muscular **ridges, bands,** and **columns,** which become smaller, more numerous, and more closely interlaced at the apex and near the margin, but which disappear in the **infundibulum.**

These projections, or **columnæ carneæ,** are usually divided into three sets: (1) mere ridges; (2) bands attached to either end but elsewhere free; and (3) a third set, the **musculi papillares,** which need a more detailed description (fig. 549).

A special band, the so-called **moderator band,** which is constant in the sheep, is occasionally a well-marked structure in the human heart, stretching between its anterior and septal walls. The **musculi papillares** are attached by their broad end to the ventricular wall, and by their extremities to tendinous cords (**chordæ tendineæ**), which restrain and harmonise the action of the valves guarding the auriculo-ventricular opening. Three of these are larger and more constant than the rest: an **anterior,** connected with the front wall above the moderator band; a **right,** near the margin, which is also attached to the anterior wall; and a **posterior,** which arises from the septum. The septal wall of the ventricle so bulges into the cavity as to make its cross-section appear crescentic.

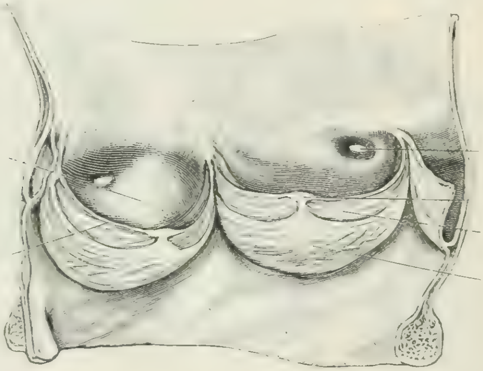
THE OPENINGS AND THEIR VALVES

The **orifice of the pulmonary artery** is circular and obliquely placed at the summit of the infundibulum near the septum. It is guarded by three valves, the **pulmonary semilunar valves.** Of these two are placed anteriorly and one posteriorly (fig. 548). Immediately above and behind each semilunar valve there is a pouch or sinus. These collectively constitute the pulmonary sinuses, or **sinuses of Valsalva.**

Each valve is formed of a fibrous layer within a reduplication of the lining membrane, which is continuous on the upper surface with the innermost coats of the artery, and on the opposite surface with endocardium of the ventricle.

In the centre of the free straight edge of each valve there is a little fibro-cartilaginous nodule, the **corpus Arantii,** and this margin is further strengthened by a delicate tendinous band. Another fibrous band in like manner strengthens the convex attached portion of the valve, and from this a third set of obliquely interlacing fibres pass throughout the whole valve towards the nodule. Two narrow crescent-shaped areas, the **lunulæ,** near the free edge on each side of the nodule, remain almost free from this fibrous invasion, and it is these thinner portions which are in apposition during closure of the valve. A fibrous ring strengthens the pulmonary orifice, giving attachment below to the muscular fibres of the heart; whilst above, opposite the sinuses of Valsalva, it is deeply hollowed into three semilunar notches. The valves are attached to the edges of these notches as well as to the horns which project inwards and separate them from one another. (See fig. 551, of the aortic valves, in which these characters are present and more strongly marked.)

FIG. 551.—INTERIOR VIEW OF THE AORTIC SEMILUNAR VALVES.



The **auriculo-ventricular opening** is oval and guarded by the **tricuspid valve.** The three triangular flaps of this valve are continuous with one another at their broad ends, and so form a continuous fold around the orifice; but beyond, they project with jagged and sharply dentated edges towards the apex of the ventricle.

The chordæ tendineæ, which chiefly arise from the papillary muscles already described, pass to their free borders and ventricular surfaces. The largest segment of the valve is placed in front, between the auriculo-ventricular orifice and the infundibulum, the smallest behind near the septum, and the third, which is the most movable, is situated on the right.

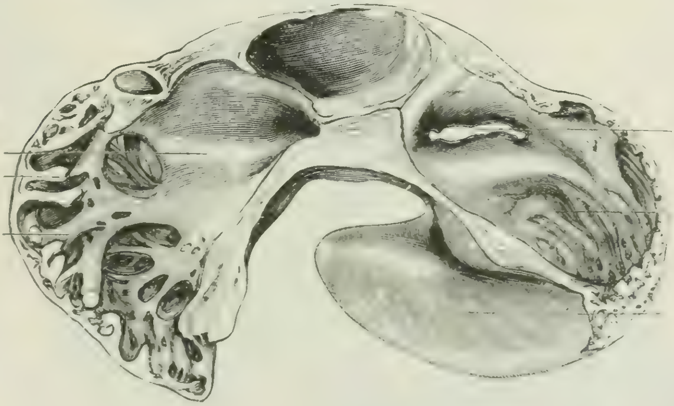
Smaller segments intervene between the larger flaps. The chordæ tendineæ, which arise in groups from the papillary muscles, divide as they pass to be attached to the edges and ventricular surfaces of the neighbouring segments. Additional cords are furnished from the ventricular walls, and especially from the septum to the small segment, and some of these are provided with little papillary muscles.

The segments of this valve, except at the extremities and margins, contain abundant fibrous and a small amount of muscular tissue. They are attached by their thickened bases to a fibrous ring which surrounds and strengthens the orifice. The surfaces which look towards the opening are smooth, whilst upon the opposite surfaces the chordæ tendineæ form an arched interlacement, which has been well likened to the fan tracery of Gothic architecture. (Macalister.)

The **left auricle** is placed behind the roots of the aorta and pulmonary artery, with the right auricle overlapping it, and lying to the right of these structures. Behind, it receives on each side the pulmonary veins, and it is separated by the pericardium from the oesophagus and the descending thoracic aorta. Its narrow and much curved appendix arches round the root of the pulmonary artery, and is the only part of the auricle to be seen from the front. The **cavity** of the auricle is smooth, with the exception of the appendix, in which the musculi pectinati are well marked.

Openings.—Besides the narrow opening which leads from the atrium into the appendix, the left auricle presents posteriorly the orifices of the four **pulmonary veins,** two of which sometimes have a single mouth, whilst a third may be present, especially on the right side. The oval **auriculo-ventricular opening** is placed below and in front. Several small orifices, the **foramina Thebesii,** are also to be found in the cavity. A crescentic indentation on the septal wall, with its concavity upwards and placed above the level of the annulus ovalis, indicates the upper border of the valve, which has grown upwards to obliterate the foramen ovale, but which now is adherent and forms part of the wall dividing the two auricles. As already observed, a small oblique orifice sometimes remains unclosed.

FIG. 552.—VIEW OF THE AURICULAR CAVITIES FROM BELOW (THE TRANSVERSE SECTION PASSING ABOVE THEIR MIDDLE).



The **left ventricle** forms the chief part of the heart behind, with its apex and left border. It is somewhat longer and narrower than the right. Its cavity is conical with the apex below and it is somewhat ovoid in transverse section. Its muscular wall, which is much thicker than that of the right ventricle, is thinnest at the apex and thickest at the junction of the upper and middle thirds.

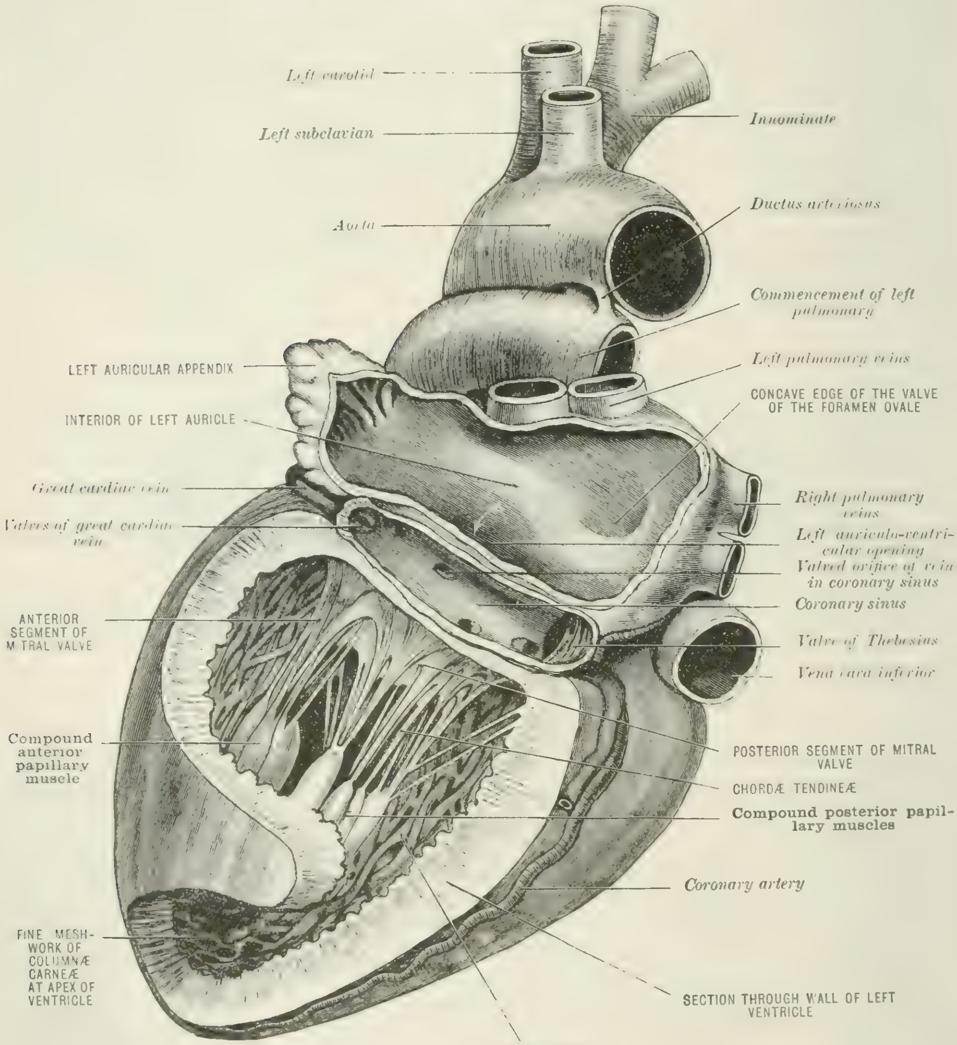
The **columnæ carneæ** are numerous, small, and closely reticulated, giving to the interior of the ventricle, especially near the apex, a cavernous appearance.

The **musculi papillares** are usually represented by two large, sometimes compound, muscular pillars, which arise from the anterior and the posterior wall respectively; and from these the **chordæ tendineæ** pass to the edges and surfaces of the two segments of the bicuspid valve.

The **orifice of the aorta** looks somewhat forwards, and is guarded by three **semilunar valves,** which are similar in structure, but present more strongly marked characters than are to be found in the corresponding valves of the pulmonary artery. One of these segments is placed anteriorly and two lie posteriorly. It is surrounded by a fibrous ring, similar to that which strengthens the pulmonary orifice, and the walls of that portion of the cavity which lies immediately below it, the aortic vestibule, are entirely fibrous.

The **auriculo-ventricular opening** is guarded by the **bicuspid valve.** Its two unequal segments are larger and thicker than those on the right side of the heart, though the orifice itself is somewhat smaller, and they are similarly separated by smaller lobes or cusps. Of the two segments, the one, which is the larger and the more free and smooth, is placed in front and to the right between the two openings, whilst the other lies behind and to the left. The fibrous ring surrounding the orifice serves to give attachment to muscular fibres as well as to the valves. By its right border it is tied to the aortic ring by fibrous tissue, which also extends to the ring surrounding the tricuspid valve. In the angular space thus bounded there is imbedded a fibro-cartilage, which in some mammals is represented by a bone which is known as the **os cordis.**

FIG. 553.—POSTERIOR VIEW OF THE LEFT CHAMBERS OF THE HEART, WITH THE GREAT VESSELS AND THE CORONARY SINUS LAID OPEN.


Left carotid
Left subclavian
Innominate
Aorta
Ductus arteriosus
Commencement of left pulmonary
Left pulmonary veins
LEFT AURICULAR APPENDIX
CONCAVE EDGE OF THE VALVE OF THE FORAMEN OVALE
INTERIOR OF LEFT AURICLE
Great cardiac vein
Right pulmonary veins
Valves of great cardiac vein
Left auriculo-ventricular opening
Valved orifice of vein in coronary sinus
Coronary sinus
ANTERIOR SEGMENT OF MITRAL VALVE
Valve of Thebesius
Vena cava inferior
Compound anterior papillary muscle
POSTERIOR SEGMENT OF MITRAL VALVE
CHORDÆ TENDINEÆ
Compound posterior papillary muscles
Coronary artery
FINE MESHWORK OF COLUMNÆ CARNEÆ AT APEX OF VENTRICLE
SECTION THROUGH WALL OF LEFT VENTRICLE
COLUMNÆ CARNEÆ

The interventricular septum which separates the cavities of the ventricles is thickest below. In the greater part of its extent it consists of muscular tissue, but its upper portion, which intervenes not only between the two ventricles but also between the left ventricle and right auricle, is a fibrous septum devoid of muscle-fibres.

THE POSITION OF THE CHIEF ORIFICES ONE TO THE OTHER AND TO THE CHEST WALL

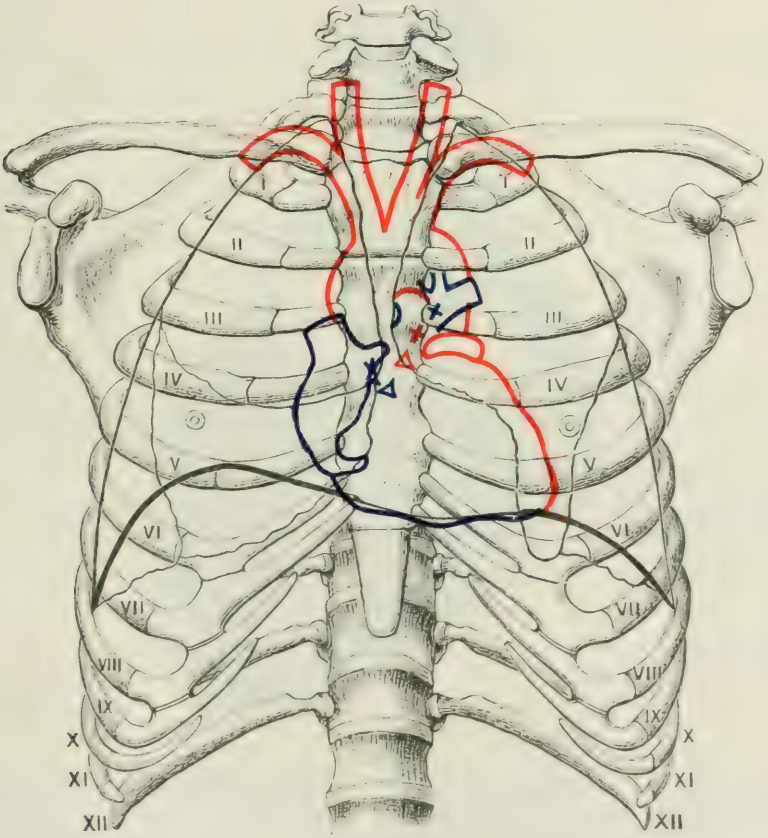
The **pulmonary orifice** is placed in front of, and to the left of the right auriculo-ventricular opening, whilst the **aortic orifice** is in front of, and to the right of the left auriculo-ventricular opening. The relation of the valved orifices to the chest wall can only be approximately determined (Fig. 547).

The **pulmonary semilunar valves,** which are anterior in position to the aortic, are placed behind the junction of the third rib with the sternum on the left side.

FIG. 554.—SHOWING THE POSITION OF THE HEART AND ITS VALVES IN RELATION TO THE CHEST WALLS.

(Reduced from Hensman and Fisher's Anatomical Outlines.)

(The right auricle and ventricle, with the pulmonary semilunar and tricuspid valves, are outlined in blue tints; whilst the left auricle and ventricle, with their corresponding valves, are indicated in red.)



The **aortic semilunar valves,** more deeply placed, correspond to the third space, close to the sternum.

The **tricuspid valve** is situated behind the sternum near the middle line, about the level of the fourth space.

The **mitral valve** lies deeply behind the sternum opposite the fourth cartilage (Fig. 547).

The **muscular walls** of the heart vary very much in thickness, and the fœtal differs from the adult heart in the relative muscularity of its chambers.

The right auricle is thinner than the left, the right measuring about one-twelfth of an inch, and the left about one-eighth of an inch in thickness. The right ventricular wall in the adult is much thinner than the left, being thickest at the base, and thinnest at the apex.

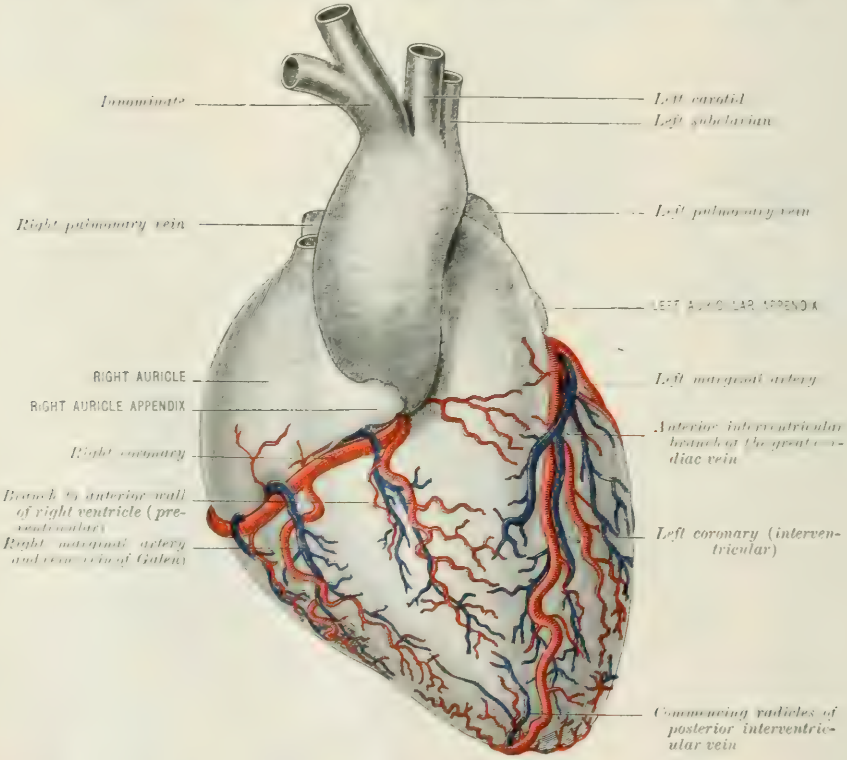
The left ventricular wall is about double the thickness of the right; and it is thickest where the ventricle is broadest, being thinner both at its base and apex.

The Vessels and Nerves

The arteries.—The two coronary arteries, right and left, arise, the right from the anterior, and the left from the left posterior sinus of Valsalva just above the free borders of the right, and of the left posterior semilunar valves.

The **right coronary artery** passes forwards between the pulmonary artery and the right auricular appendix, and then winds to the right border of the heart, around which it turns to gain its posterior surface. In this course it lies in the auriculo-ventricular groove. At the commencement of the posterior interventricular groove it divides into its two main branches, one of which, still passing onwards in the auriculo-ventricular groove, anastomoses with the left coronary, whilst the other (**interventricular**) descends in the furrow between the ventricles towards the apex, near which it anastomoses with branches derived from the left coronary artery which have reached the posterior surface of the heart after passing around its apex. In this course the right coronary artery supplies branches to the right auricle (**auricular**) and roots of the pulmonary artery and aorta, as well as one that descends near the right border of the heart (**right marginal**), and a second (**preventricular**) to the anterior wall of the right ventricle. It supplies both ventricles and the septum.

FIG. 555.—ANTERIOR VIEW OF THE HEART, SHOWING ITS ARTERIES AND VEINS.

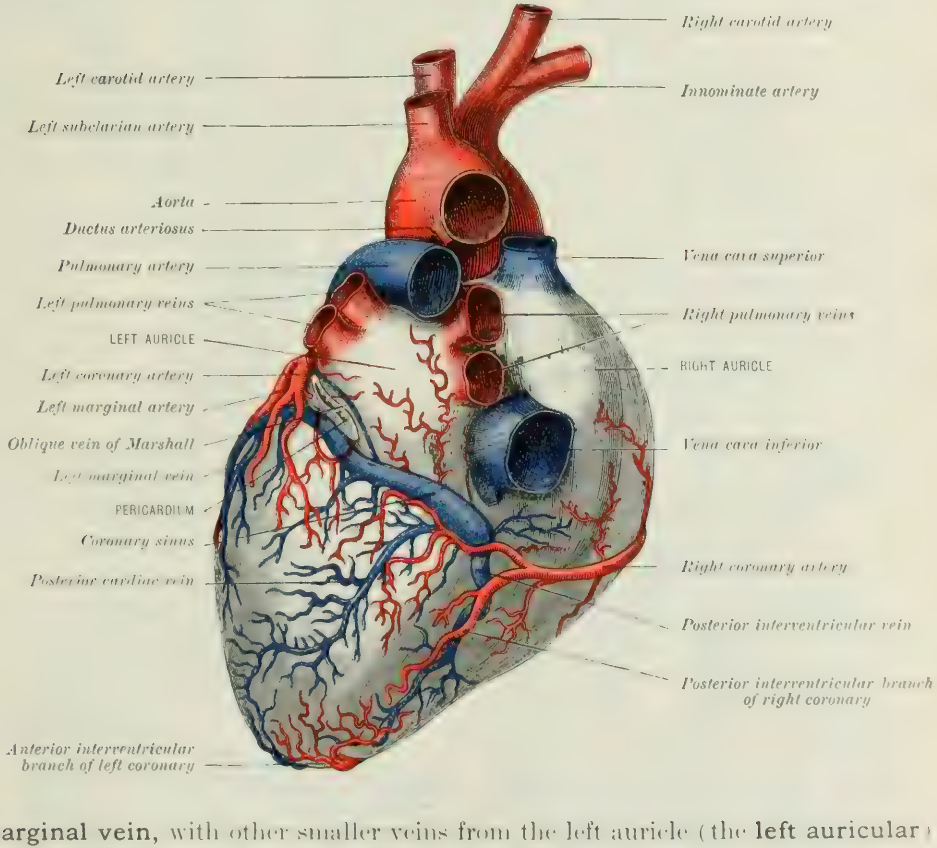

Innominate
Left carotid
Left subclavian
Right pulmonary vein
Left pulmonary vein
LEFT AURICULAR APPENDIX
RIGHT AURICLE
RIGHT AURICLE APPENDIX
Left marginal artery
Right coronary
Anterior interventricular branch of the great cardiac vein
Branch to anterior wall of right ventricle (preventricular)
Right marginal artery and vein (vein of Galen)
Left coronary (interventricular)
Commencing radicles of posterior interventricular vein

The **left coronary artery** passes for a short distance forwards, between the pulmonary artery and the left auricular appendix, and then divides into two principal branches, one of which descends in the interventricular groove to the apex of the heart (**interventricular**), around which it sends branches to anastomose with the right coronary; whilst the other winds to the back of the heart in the auriculoventricular groove, to anastomose after division with the corresponding twigs of the right artery. In this course it gives off a branch which descends near the left border of the heart (**left marginal**), as well as smaller branches to the left auricle, both ventricles, and the commencement of the aorta and pulmonary vessels.

The **cardiac** or **coronary veins** accompany the coronary arteries and return the blood from the walls of the heart.

The (so-called) **great cardiac vein** ascends in the anterior interventricular sulcus, passing round the left side of the heart to its posterior surface in the auriculoventricular groove to terminate in the commencement of the coronary sinus. Its mouth is usually guarded by two valves, and it receives in its course the **left marginal vein,** with other smaller veins from the left auricle (the **left auricular**) and ventricle, all of which are guarded by valves.

FIG. 556.—POSTERIOR VIEW OF THE HEART, SHOWING ITS ARTERIES AND VEINS.

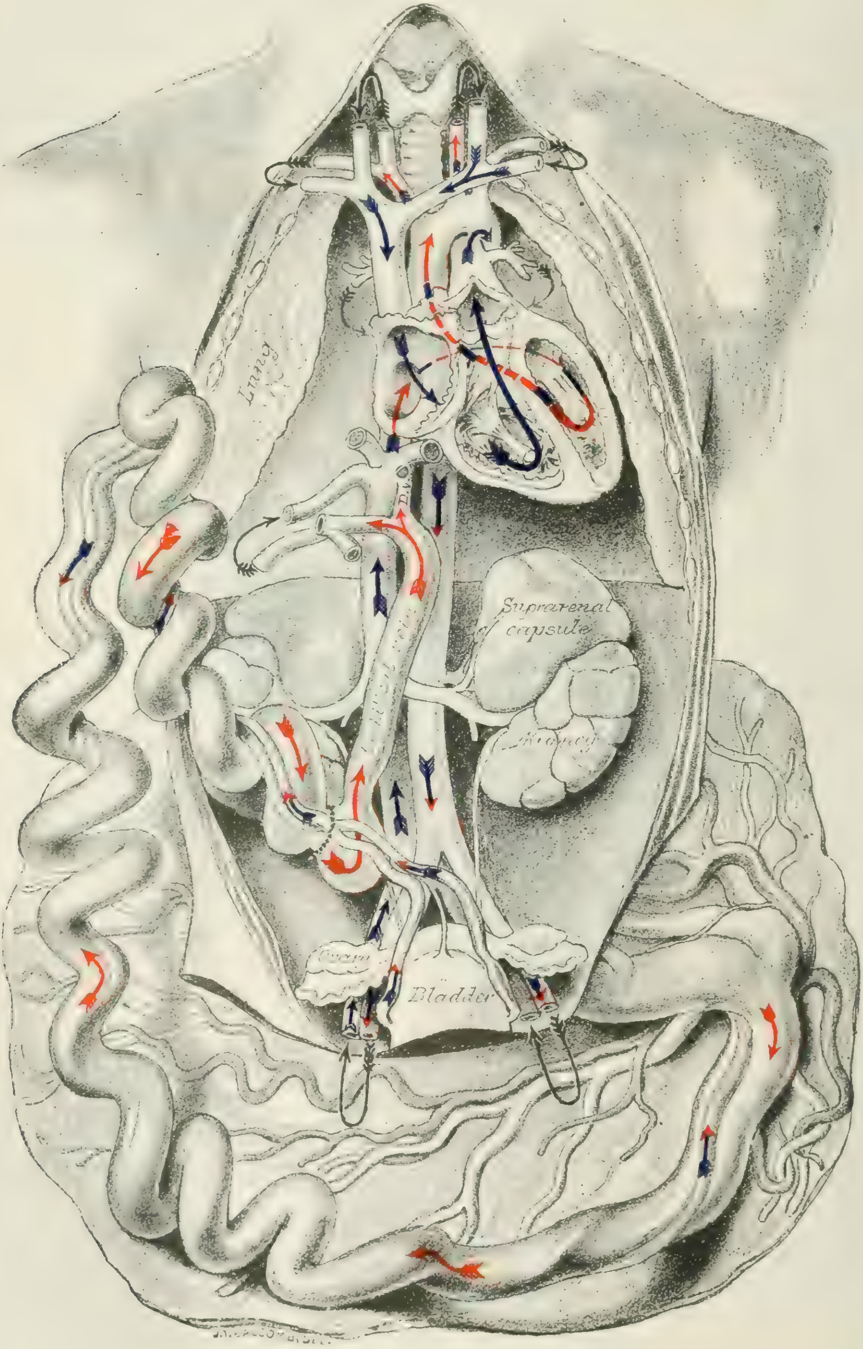

Right carotid artery
Left carotid artery
Innominate artery
Left subclavian artery
Aorta
Ductus arteriosus
Vena cava superior
Pulmonary artery
Left pulmonary veins
Right pulmonary veins
LEFT AURICLE
RIGHT AURICLE
Left coronary artery
Left marginal artery
Oblique vein of Marshall
Vena cava inferior
Left marginal vein
PERICARDIUM
Coronary sinus
Right coronary artery
Posterior cardiac vein
Posterior interventricular vein
Posterior interventricular branch of right coronary
Anterior interventricular branch of left coronary

The **posterior cardiac vein** (**posterior interventricular**), sometimes the larger of the two chief veins, communicates with the foregoing at its commencement on the anterior surface above the heart's apex. It ascends in the posterior interventricular groove, receiving blood from the ventricular walls, and joins the coronary sinus, through an orifice guarded by a single valve, close to its termination.

The **anterior cardiac veins** (**preventricular**) consist of several small branches from the front of the right ventricle, which open separately into the right auricle, or into the right auricular vein; and a **right marginal vein** (**vein of Galen**), which joins the coronary sinus near its termination, or opens separately into the lower part of the right auricle (Figs. 549, 555).

The **coronary sinus** may be regarded as a much dilated terminal portion of the great cardiac vein. It is about an inch in length, covered by muscular fibres from

FIG. 557.—ANTERIOR VIEW OF A FŒTUS. THE HEART, VESSELS, AND CHIEF ORGANS DISPLAYED, WITH THE PLACENTA AND UMBILICAL CORD.


Lung
D.V.
Suprarenal capsule
Kidney
Ovary
Bladder

the auricle; and lies in the auriculo-ventricular groove on the posterior surface of the heart. Its cardiac orifice with the coronary (Thebesian) valve has already been described. Besides the tributary veins already named, a small **oblique vein of Marshall** may sometimes be traced from the vestigial fold to the sinus. This little vein, which is not always pervious or easy of demonstration, never possesses a valve at its orifice, and like the coronary sinus formed a part of the left superior vena cava of early fœtal life. The sinus also receives the posterior interventricular vein, one or more right auricular branches, and several **post-ventricular veins** from the back of the left ventricle.

The **cardiac nerves** descend into the superior mediastinum, passing in front of and behind the arch of the aorta, to unite in the formation of the superficial and deep cardiac plexuses.

The **deep cardiac plexus,** the larger and more important, is placed immediately above the pulmonary artery at its point of division, lying between the trachea and arch of the aorta. It is usually formed by the interlacement of all the cardiac branches, with the exception of the left superior cardiac branch from the sympathetic and the left inferior cardiac from the pneumogastric.

A meshwork of branches descends from the plexus, some passing to the right and some to the left. The greater number of the right branches follow the course of the right coronary artery to form the right coronary plexus; some, however, pass forwards to enter the superficial cardiac plexus.

The left branches, which are both larger and more numerous, descend beneath the corresponding pulmonary artery to join the left coronary plexus; some of these pass right and left to join the anterior pulmonary plexuses at the roots of the lungs.

The **superficial cardiac plexus,** which lies in front of the right pulmonary artery as it passes beneath the arch of the aorta, is formed by the interlacement of the left superficial cardiac branch from the sympathetic, the inferior cardiac from the pneumogastric, together with branches derived from the deep plexus. A small ganglion, the **cardiac ganglion of Wrisberg,** is sometimes found close to the right side of the ductus arteriosus. The greater number of the filaments from this plexus go to the right coronary plexus. Some, however, reach the left anterior pulmonary plexus.

The **coronary plexuses** follow the course of the vessels, and their filaments enter the muscular walls of the heart. Minute ganglia are connected with these filaments, and are especially abundant near the auriculo-ventricular groove.

Peculiarities of the Fœtal Heart

The fœtal heart is at first almost vertical in **position,** but during the latter half of intra-uterine life it gradually assumes the oblique position it retains in the adult.

Its **weight** in relation to the body varies considerably. Thus at the second

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The black connecting arrows indicate the course of the circulation through the head and neck, the upper extremities, the lungs, the liver, and the lower extremities.

The red arrows show the direction of the current from the placenta, through the umbilical vein, ductus venosus (D. V.) and liver, to the upper portion of the inferior vena cava.

The red arrows with the blue tails and the dotted line show the course of the impure blood, as it enters the right auricle through the inferior vena cava, and traverses the foramen ovale, guided by the Eustachian valve, to gain the left auricle, left ventricle, and aorta, to be distributed by its chief branches to the head and neck and upper extremities.

The blue arrows are placed on the superior and inferior venæ cavæ, and some of their main tributary trunks.

The stream derived from the superior cava passes through the right auricle—in front of that already described—to reach the right ventricle; thence it passes into the pulmonary artery (a small portion only reaching the lungs through the right and left pulmonary branches), ductus arteriosus, and descending aorta.

The stream derived from the inferior cava mixes with the blood of the umbilical vein, and that which has passed through the liver, beyond the junction of the ductus venosus and hepatic veins.

The blue arrows with the red heads show the course of the blood through the descending aorta to the lower extremities, and through the umbilical arteries to the placenta.

The colours of the arrows roughly indicate the proportion of pure and impure blood to the different parts of the circulation.

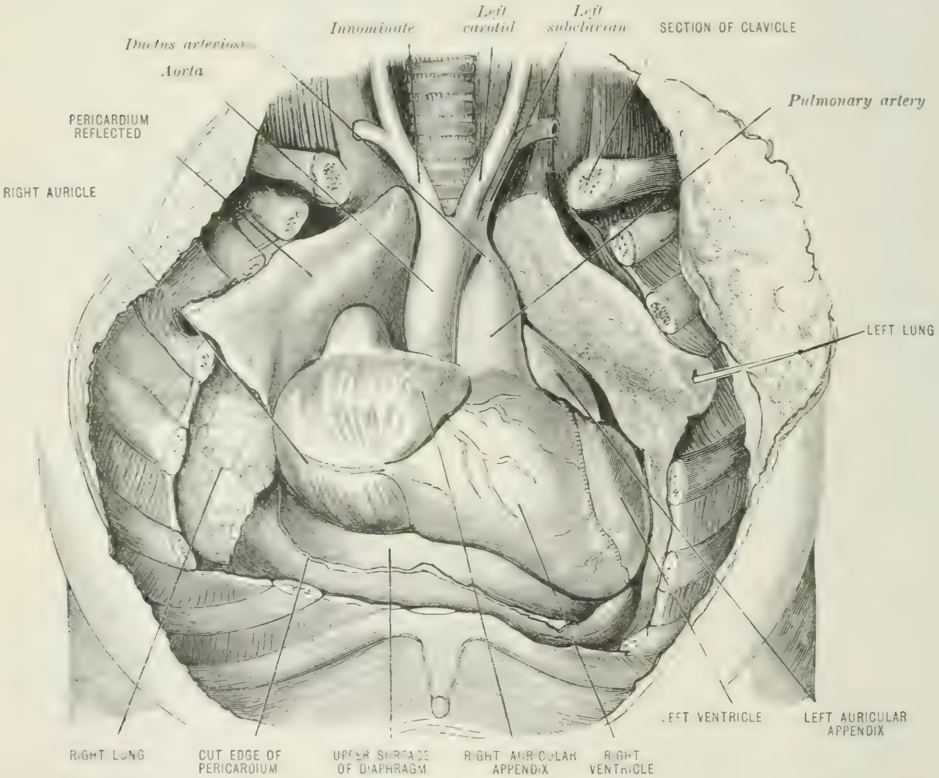
month it is about 1 to 50; at birth it is 1 to 120; whilst in the adult it is about 1 to 160.

The **auricular portion** is at first more capacious than the ventricular, and the **right auricle** is larger than the left. The **ventricular walls** are at first about equal in thickness, but at birth the left wall is the thicker of the two.

The **foramen ovale** is largest about the sixth month of intra-uterine life, and there is up to this period a direct communication between the two auricles. The **valve of the foramen ovale,** however, gradually advancing upwards beyond the annulus, on its left side, acts as a perfect valve during the latter half of fœtal life, and thus prevents the return of blood into the right auricle.

The **Eustachian valve** has already been described; it is of large size in the fœtal heart, and serves to direct the current of blood from the inferior cava into the left auricle.

FIG. 558.—ANTERIOR VIEW OF HEART AND GREAT VESSELS OF FŒTUS, THE ANTERIOR CHEST WALL BEING REMOVED AND THE HEART SAC OPENED.


Ductus arteriosus
Aorta
Innominate
Left carotid
Left subclavian
SECTION OF CLAVICLE
Pulmonary artery
PERICARDIUM REFLECTED
RIGHT AURICLE
LEFT LUNG
LEFT VENTRICLE
LEFT AURICULAR APPENDIX
RIGHT LUNG
CUT EDGE OF PERICARDIUM
UPPER SURFACE OF DIAPHRAGM
RIGHT AURICULAR APPENDIX
RIGHT VENTRICLE

The **ductus arteriosus** continues the pulmonary artery onwards to the concavity of the arch of the aorta, to a point just beyond the origin of the left subclavian artery, and so transmits the blood from the right ventricle into the descending aorta. The ductus arteriosus during the growth of the pulmonary artery becomes ultimately associated with its left branch.

The fœtal circulation.—The right auricle of the heart receives its blood from both venæ cavæ, as well as from the coronary sinus. That which is conveyed by the superior cava is venous blood returned from the head and neck and upper extremities. The inferior cava returns the blood from the lower half of the body, as well as that which comes from the placenta through the umbilical vein. This latter stream reaches the inferior cava, in part directly through the ductus venosus, and in part through the liver and hepatic veins.

The blood of the superior vena cava passes from the right auricle into the right ventricle, and thence through the pulmonary artery (a small portion only reaching the lungs) and ductus arteriosus to the descending aorta. Through this trunk it is conducted to the lower half of the body as well as to the placenta through the umbilical arteries. From these parts it is returned to the right auricle by the inferior cava, which also receives the blood returning from the placenta as already described.

The current which passes through the inferior cava only in a slight degree mingles with that of the superior cava, as it is guided directly through the foramen ovale by means of the Eustachian valve into the left auricle. This cavity also receives a small quantity of blood (which has traversed the lungs) through the pulmonary veins. From the left auricle the blood current passes into the left ventricle, and thence through the aorta to the head and neck and the upper extremities.

SECTION VIII

THE ORGANS OF DIGESTION

THE ORGANS ABOVE THE DIAPHRAGM

By ARTHUR HENSMAN, F.R.C.S.

REVISED FOR SECOND EDITION BY ARTHUR ROBINSON, M.D., M.R.C.S., LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

THE MOUTH

THE **mouth** is the cavity at the commencement of the alimentary canal which contains the organs of taste and mastication and the greater part of those of speech. It communicates with the exterior through a transverse orifice (the **buccal orifice**) and with the pharynx through the **fauces.**

It is bounded anteriorly and laterally by the teeth and alveolar arches; external to which is a second cavity, often described as the **vestibule** of the mouth, which is enclosed by the lips and cheeks. Its roof is formed by the hard palate, its floor by the tongue, with the mucous membrane reflected from it to the inner surface of the gums over the sublingual glands and the Whartonian ducts; and posteriorly it opens into the fauces. It is lined by mucous membrane, which is continuous with that of the pharynx, and at the outer margin of the lips it is continuous with the skin.

The **buccal orifice** is a horizontal slit, the extremities or "angles" of which are opposite the first bicuspid teeth. The orifice is bounded by the **upper** and **lower lips,** of which the former is distinguished by a median tubercle, the remains of the free extremity of the fronto-nasal process. The **lips** are covered by a dry mucous membrane, bright red in color, and extremely sensitive, containing large numbers of vascular papillæ, in many of which are nerve-terminations resembling touch-corpuscles. Near to the junction of the skin and mucous membrane are numerous sebaceous follicles, but these are devoid of hair-bulbs.

The substance of the lips consists of the orbicularis oris and a quantity of areolar tissue in which are embedded the coronary vessels, lymphatics, and small branches of the infraorbital and mental nerves. Around the orifice of the mouth on its inner aspect, and placed beneath the mucous membrane, are a number of small lobulated glands known as the "labial glands."

The **cheeks** consist of the buccinator muscle, covered externally, first by a stratum of subcutaneous fat, then by the dermal muscles, zygomatici and risorius, and lastly by the skin. They are lined with mucous membrane, which contains numerous buccal glands similar to, but smaller than, the labial glands. Between the integument and the buccinator, in each cheek, besides vessels and nerves there are several glands, the molar glands, whose ducts pierce the buccinator and open in the vestibule opposite the last molar teeth, and a large quantity of fat, which gives rotundity to the features, and constitutes what is sometimes spoken of as the sucking cushion of the cheek. Opposite the second upper molar tooth is a papilla which marks the opening of the duct of the parotid gland.

The **gums** are formed by a layer of tough areolar tissue covering the alveolar processes, and firmly attached to their periosteum.

They are covered on both aspects by the mucous membrane of the mouth, the inner surfaces receiving reflexions from the sides and anterior extremity of the tongue, a median fold forming the frænum of that organ; and the outer surfaces receiving reflexions from the cheeks and lips. In the median line above and below the orifice of the mouth are folds of mucous membrane, forming the fræna labiorum, of which the upper is the more marked.

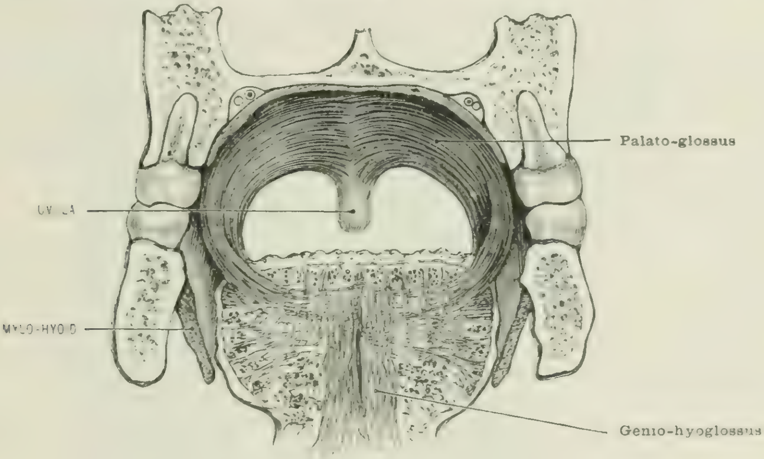
THE PALATE

The **palate** consists of two portions, the anterior or hard palate, and the posterior or soft palate.

The **hard palate,** which is limited in front and laterally by the alveolar processes, ends posteriorly in a free border to which the soft palate is attached.

The mucous membrane which covers it is corrugated, thick and somewhat pale, and is firmly bound down to its periosteum. In the median line of the palate is a ridge called the raphe; at the anterior extremity of this is a small papilla which marks the inferior opening of the anterior palatine canal, and extending from its sides, anteriorly, are five or six transverse ridges. The mucous membrane covering the hard palate receives its nerve-supply from the anterior palatine and naso-palatine nerves.

Fig. 558a.—Palato-glossus Muscle, seen from the Mouth, with Section of Base of Tongue.



The **SOFT PALATE** (fig. 560) is attached to the posterior border of the hard palate, of which it forms a backward prolongation hanging down at the back of the mouth, and thus partially separating the latter cavity from the pharynx. Its sides are merged in the pharyngeal wall, and its lower border is free.

From the centre of this border a somewhat conical process, the **uvula,** depends, and from the base of this two folds of mucous membrane on each side extend in an outward and downward direction, receiving the name of the **pillars of the fauces.**

The **anterior pillar** is formed principally by the palato-glossus muscle, and its direction is downwards, outwards, and forwards to the side of the base of the tongue.

The **posterior pillar** is formed principally by the palato-pharyngeus. It approaches more nearly to its fellow of the opposite side than does the anterior. Its direction is outwards, downwards, and backwards, and there thus exists between it and the anterior pillar a triangular space, the **tonsillar recess.**

The space between the anterior pillars is known as the **isthmus of the fauces,** and forms the buccal opening of the pharynx. It is bounded below by the tongue, above by the soft palate, and laterally by the pillars of the fauces.

The **anterior surface of the soft palate** is concave, directed forwards and downwards, and is continuous with the lower surface of the hard palate; its

posterior surface, which is convex, is a continuation of the floor of the nasal cavity, and it forms a part of the anterior wall of the pharynx.

Structure.—The soft palate is a fold of mucous membrane enclosing an aponeurosis, muscles, vessels, and nerves. It is marked in the middle line by a raphe indicating the line of junction of the two halves from which it was formed.

The posterior layer of the mucous fold which is directed towards the cavity of the pharynx is continuous with the nasal mucous membrane; the anterior layer lies in the posterior boundary of the mouth and is continuous with the mucous membrane of the hard palate; the lower margin is free. Glands are numerous in both layers, but more especially in the anterior.

The aponeurosis is attached above to the posterior margin of the hard palate; laterally it is continuous with the aponeurotic layer of the pharyngeal wall; below, towards the lower margin of the soft palate, it gradually disappears, and it gives attachment to fibres of the levator palati and the palato-pharyngeus and to the tendon of the tensor palati.

The muscles are arranged in layers either behind or in front of the aponeurosis, and in a horizontal section of the soft palate the following layers are met with from behind forwards: (1) The mucous membrane on the pharyngeal surface; (2) the posterior layer of palato-pharyngeus fibres; (3) the azygos uvulæ; (4) the levator palati; (5) the anterior layer of palato-pharyngeus fibres; (6) the palatal aponeurosis with the tensor palati; (7) the palato-glossus; and (8) the mucous membrane on the buccal aspect.

The **Palato-Glossus** is described on page 453.

The **Palato-Pharyngeus**—named from its attachments—is a thin sheet.

Origin.—(1) From the aponeurosis of the soft palate by two heads which are separated by the insertion of the levator palati; (2) one or two narrow bundles from the lower part of the cartilage of the Eustachian tube (*salpingo-pharyngeus*).

Insertion.—(1) By a narrow fasciculus into the posterior border of the thyroid cartilage near the base of the superior cornu; (2) by a broad expansion into the fibrous layer of the pharynx at its lower part.

Structure.—The upper head of the muscle consists of scattered fibres which blend with the opposite muscle across the middle line; the lower head is thicker, and follows the curve of the posterior border of the palate. The two heads with the fasciculus from the Eustachian tube form a compact muscular band in the posterior pillar of the fauces; the fibres mingle with those of the stylo-pharyngeus, at the lower border of the superior constrictor, and then expand upon the lower part of the pharynx.

Nerve-supply.—From the pharyngeal plexus.

Action.—(1) Approximates the posterior pillars of the fauces; (2) depresses the soft palate; (3) elevates the pharynx.

The **Levator Palati**—named from its action on the soft palate—is somewhat rounded in its upper, but flattened in its lower half.

Origin.—(1) The under surface of the petrosal anterior to the orifice of the carotid canal; (2) the lower margin of the cartilage of the Eustachian tube.

Insertion.—The aponeurosis of the soft palate; the terminal fibres of the muscles of each side meet in the middle line in front of the azygos uvulæ.

Structure.—Its origin is by a short tendon; the muscle then becomes fleshy, and continues so to its insertion.

Nerve-supply.—It is usual to describe this muscle as being innervated by the facial through the petrosal branch of the Vidian. The nerve is supposed to reach the muscle through the small palatine nerve from Meckel's ganglion. Stimulation of the facial trunk within the skull of monkeys produces no result on the soft palate, whereas stimulation of the eleventh causes elevation of the soft palate on the same side. The motor branch probably passes to the palate in the upper branches of the pharyngeal plexus (Horsley and Beevor).

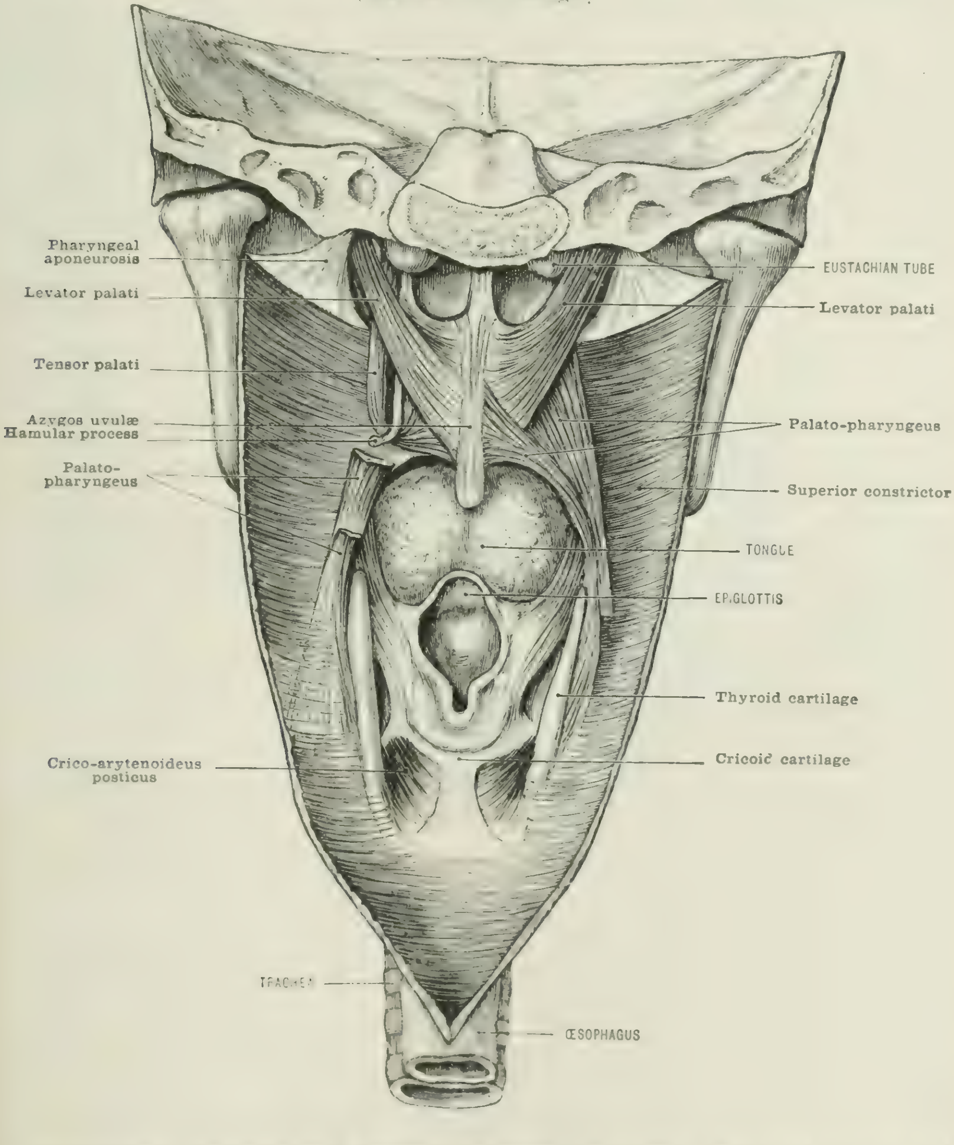
Action.—(1) To raise up the palate, and bring it in contact with the posterior wall of the pharynx; (2) when the muscle contracts it presses up and closes the pharyngeal orifice of the Eustachian tube (Cleland). This action is not admitted by many anatomists.

The Tensor Palati—named from its action on the soft palate—is a thin, flat, and narrow sheet.

Origin.—(1) The scaphoid fossa at the root of the internal pterygoid plate; (2) the alar spine of the sphenoid; (3) the outer side of the pharyngeal extremity of the Eustachian tube.

Insertion.—(1) Into the transverse ridge on the under surface of the horizontal plate of the palate bone; (2) the aponeurosis of the soft palate.

FIG. 558B.—VIEW OF MUSCLES OF SOFT PALATE, AS SEEN FROM WITHIN THE PHARYNX. (Modified from Bourgery.)


Pharyngeal aponeurosis
Levator palati
Tensor palati
Azygos uvulæ
Hamular process
Palato-pharyngeus
Crico-arytenoideus posticus
TRACHEA
EUSTACHIAN TUBE
Levator palati
Palato-pharyngeus
Superior constrictor
TONGUE
EPIGLOTTIS
Thyroid cartilage
Cricoid cartilage
ŒSOPHAGUS

Structure.—Its belly as it descends between the internal pterygoid muscle and the internal pterygoid plate is muscular. On approaching the hamular process it becomes tendinous, and continues so to its insertion. A bursa is interposed between the hamular process and the tendon. The belly of the muscle is at nearly a right angle with its tendon.

Nerve-supply.—From the otic ganglion on the mandibular division of the fifth nerve.

Actions.—(1) Tightens the soft palate; (2) opens the Eustachian tube during deglutition.

The **Azygos Uvulæ**—named because it was supposed to be a single muscle.

Origin.—(1) From the aponeurosis of the soft palate; (2) the nasal spine of the palate bone.

Insertion.—Into the uvula.

Structure.—The muscle consists of two narrow parallel strips lying on each side of the middle line of the palate.

Nerve-supply.—Probably from the same source as the levator palati.

Action.—To draw up the uvula.

The **Mucous Membrane of the soft palate** is continuous with that of the mouth on its anterior aspect, and with that of the nasal chamber on its posterior surface; its epithelium is columnar and ciliated in the vicinity of the Eustachian tube, but elsewhere it is squamous and not ciliated. The **glands** form an especially thick layer on its superior aspect.

Arterial supply of the soft palate.—(1) Ascending palatine of facial; (2) palatine branch of ascending pharyngeal; (3) twigs from descending palatine of internal maxillary, which enter the smaller palatine canals, and are distributed to the soft palate and tonsils, and communicate with the ascending palatine of the facial artery; (4) lingual artery, by twigs from the dorsal branch.

Nerves to the soft palate.—(1) Branches from Meckel's ganglion ('small or posterior palatine' and 'external palatine nerve'); (2) tonsillitic branches of glosso-pharyngeal nerve; and (3) the nerves supplying the muscles.

The **TONSILS** (figs. 507 and 560) are two bodies situated one in each of the recesses between the anterior and posterior pillars of the fauces and beneath a small fossa, the supra-tonsillar recess, which is the remains of the second visceral cleft. They are about an inch (20–25 mm.) in length, and half an inch (12–15 mm.) in width and thickness; but their size is liable to considerable variation.

On their inner surfaces are a number of puncture-like openings (twelve to fifteen on each tonsil), which form the orifices of small recesses or crypts, into which numerous follicles open. The mucous membrane is continued into, and forms a lining for, these follicles; their walls are surrounded by an aggregation of closed capsules somewhat similar to the solitary glands of the intestine, and they contain a thick secretion.

The tonsil corresponds in position with the angle of the jaw; it is in relation externally with the superior constrictor muscle, which separates it from the ascending pharyngeal artery; about one inch externally and posteriorly to it is the internal carotid artery, and still more externally the internal pterygoid muscle.

The **arteries of the tonsil** are five in number, viz.:—(1) Dorsalis linguae from the lingual; (2) ascending pharyngeal from the external carotid; (3) ascending palatine from the facial; (4) tonsillar from the facial; and (5) descending palatine from the internal maxillary.

The **veins of the tonsil** form a plexus which lies upon the outer side of the gland, and opens externally into the pharyngeal plexus.

The lymphatics of the tonsil communicate with those of the dorsum of the tongue, and they pass to a gland which lies near the angle of the jaw.

The **nerves of the tonsil** are branches of the fifth and glosso-pharyngeal.

THE SALIVARY GLANDS

The three chief salivary glands are the **parotid**, the **submaxillary** (mandibular), and the **sublingual**. These all pour their secretions into the cavity of the mouth.

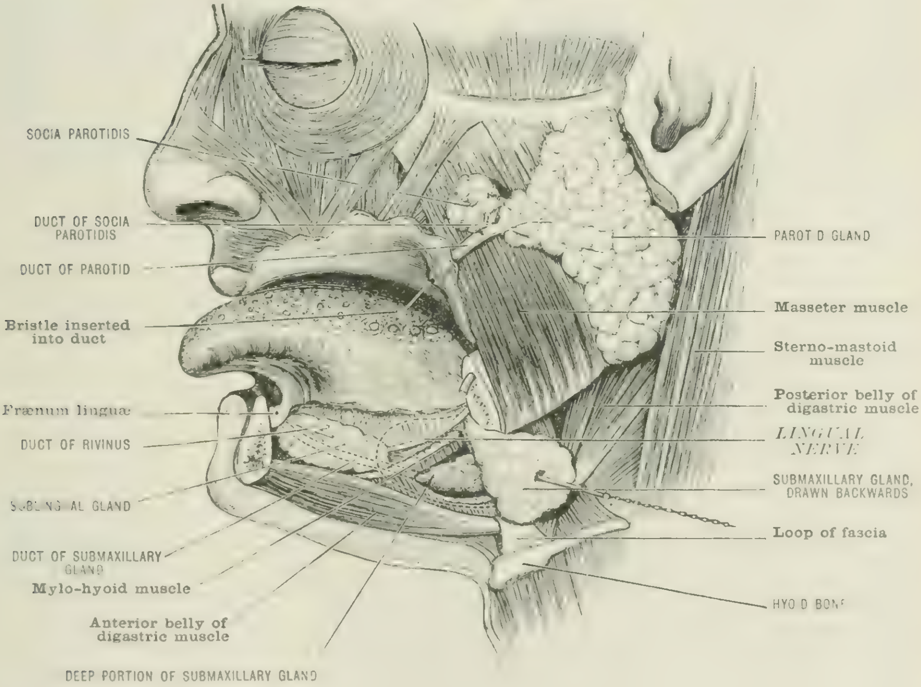
The **PAROTID GLAND** is the largest of the salivary glands. It lies just below and in front of the ear, and it varies from a little over half an ounce to an ounce in weight.

Its **superficial surface** is limited above by the root of the zygoma; behind, by the external auditory meatus, the mastoid process, and the sterno-mastoid muscle with the posterior belly of the digastric; anteriorly, it extends for a varying distance over the masseter muscle; and below, it is bounded by a line passing from the angle of the jaw backwards.

It is enclosed in an aponeurotic capsule. The capsule is continuous with the deep cervical fascia and it is strengthened at the lower part of the gland, where it extends from the styloid process to the angle of the jaw as the stylo-maxillary ligament which intervenes between the parotid and submaxillary glands. Above the capsule is attached to the lower margin of the tympanic plate of the temporal bone and to the posterior border of the Glasserian fissure.

The gland is somewhat prismatic in form, possessing three borders and surfaces and two extremities. The outer surface is covered by fascia and skin and in the lower part of its extent by platysma. Embedded in it are several superficial lymphatic glands which receive afferent vessels from the temple, cheek, eyebrows, eyelids, and from the outer aspect of the pinna. The posterior surface is in relation with the posterior belly of the digastric, the styloid process, the styloid group of muscles, the mastoid process, and the posterior auricular artery. A backward process of this surface which embraces the styloid process and insinuates itself between the carotid arteries is known as the carotid lobe. The anterior surface is in contact with the posterior border of the ramus of the jaw by which it is grooved and with the internal pterygoid muscle. It sends forwards an irregular process, the pterygoid lobe, between the pterygoid muscles. The anterior border is irregular and thin; it extends forwards for a variable distance over the masseter muscle, the duct and several branches of the facial nerve emerge from it, and in front of it, above the duct, there is a small separate lobe, the socia parotidis. The posterior border is in relation below with the sterno-mastoid, and above with the mastoid process. The internal border is separated from the wall of the pharynx by the carotid vessels, the internal jugular vein, and the ninth, tenth, and eleventh cranial nerves. The upper extremity lies in the posterior part of the glenoid fossa of the

FIG. 559.—THE SALIVARY GLANDS.


SOCIA PAROTIDIS
DUCT OF SOCIA PAROTIDIS
DUCT OF PAROTID
Bristle inserted into duct
Frænum linguæ
DUCT OF RIVINUS
SUBLINGUAL GLAND
DUCT OF SUBMAXILLARY GLAND
Mylo-hyoid muscle
Anterior belly of digastric muscle
DEEP PORTION OF SUBMAXILLARY GLAND
PAROTID GLAND
Masseter muscle
Sterno-mastoid muscle
Posterior belly of digastric muscle
LINGUAL NERVE
SUBMAXILLARY GLAND, DRAWN BACKWARDS
Loop of fascia
HYOID BONE

temporal bone, behind the condyle of the jaw, and in contact with the tympanic plate: the superficial temporal artery and the temporal branch of the facial nerve emerge from its outer side. The lower extremity rests upon the stylo-maxillary ligament which separates it from the posterior end of the submaxillary gland.

Within the substance of the gland are the following structures: The upper part of the external carotid artery with its superficial, temporal, and internal maxillary branches; the commencements of the transverse facial, orbital, and middle temporal branches of the superficial temporal artery, and the deep auricular branch of the internal maxillary trunk; the temporo-maxillary vein, its tributaries, and its two terminal branches; the facial nerve, its cervico-facial and temporo-facial divisions crossing the temporo-maxillary vein horizontally, and their terminal branches; the auriculo-temporal nerve, branches of the great auricular nerve, and a few deep lymphatic glands which receive afferent vessels from the posterior part of the nasal fossa, the soft palate, and the external auditory meatus.

The **duct of the parotid** (Stenson's) issues from the anterior border of the gland and crosses the masseter a finger's breadth below the zygoma. It penetrates the fat of the cheek and the fibres of the buccinator muscle, between which and the mucous membrane it runs for a short distance before it terminates on the summit of a little papilla, by a minute orifice. This opening is placed opposite the crown of the second upper molar tooth. The duct commences by numerous branches, which converge towards the anterior border of the gland, and receives in its passage across the masseter the duct of the socia parotidis. The canal is about the size of a crow-quill. Its mucous membrane is covered by a columnar epithelium. The coat of the duct is thick and tough, and consists of fibrous tissue intermixed with contractile fibres.

The **arteries** are derived from those lying in the gland substance and from the posterior auricular artery.

The **veins** terminate in the temporo-maxillary trunk.

The **nerves** are derived from the facial, great auricular, the carotid plexus of the sympathetic, and the auriculo-temporal. The latter also conveys a branch derived from the glosso-pharyngeal through the lesser petrosal and the otic ganglion. The **lymphatics** terminate in the superficial and deep cervical glands.

The parotid gland has been observed to retain its primitive condition, lying over the mandible and masseter muscle. Its lobes are absent in early childhood.

The **SUBMAXILLARY GLAND** weighs from two to three drachms and it is enclosed in a capsule of deep cervical fascia, except externally, where it is in contact with the body of the jaw. It consists of two portions, the superficial and the deep. The superficial portion is much larger than the deep portion; it occupies the fore part of the submaxillary triangle and is prismatic in form, possessing three surfaces and two extremities. The external surface lies in the submaxillary fossa on the inner side of the body of the jaw, and is in relation posteriorly with the internal pterygoid muscle. The lower surface looks downwards and outwards: it is covered by deep fascia, platysma, superficial fascia, and skin; several superficial lymphatic glands, which receive afferent vessels from the lower part of the face, lie upon or embedded in it, and it is crossed by the facial vein and some branches of the facial nerve. The internal surface rests upon the mylo-hyoid, hyo-glossus, and stylo-glossus muscles, and between it and the mylo-hyoid muscle are the mylo-hyoid nerve and artery and the submental branch of the facial artery. The anterior extremity is in contact with the anterior belly of the digastric; the posterior extremity is grooved by the facial artery and is in relation with the stylo-maxillary ligament and the posterior belly of the digastric.

The deep portion is a mere tongue-like projection which rises from the internal surface of the superficial portion at the posterior border of the mylo-hyoid muscle. It runs forwards and upwards, in company with the duct, under cover of the mylo-hyoid and upon the hyo-glossus, stylo-glossus, and genio-glossus muscles; at its commencement the submaxillary ganglion lies just above it, and at its termination it is in close relation with the sublingual gland.

The **duct of the submaxillary gland** (Wharton's) springs from the deep surface of the superficial part of the gland; it passes forwards and inwards accompanying the deep lobe just described, to open by a small orifice on the summit of a papilla by the side of the frænum of the tongue. In this course it is crossed superficially by the lingual nerve. It lies at first between the mylo-hyoid and hyo-glossus; next, between the mylo-hyoid and genio-hyo-glossus; and lastly, under cover of the mucous membrane of the mouth, between the genio-hyo-glossus and the sublingual gland. The duct is about two inches (5 cm.) in length, and has comparatively thin coats. It is lined by columnar epithelium.

The **arteries** to the gland are derived from the facial and lingual, and they are accompanied by corresponding veins.

The **nerves** proceed from the submandibular ganglion, from the mylo-hyoid of the mandibular nerve, and from branches of the sympathetic.

The **SUBLINGUAL GLAND**—the smallest of the salivary glands—is about one drachm in weight. It lies beneath the fore part of the tongue and mucous membrane of the floor of the mouth, resting deeply upon the mylo-hyoid muscle. Its position is indicated by a ridge of mucous membrane, the sublingual ridge, which runs outwards and backwards from the frænum. It is limited externally by the sublingual fossa of the mandible, and internally by the genio-hyo-glossus, stylo-glossus, and Wharton's duct; in front it touches its fellow, and behind it approaches the deep lobe of the submaxillary gland.

The duct from the main portion of the gland—the **duct of Rivinus** or **Bartholin**—runs alongside the submaxillary duct, and opens either into it or on the same papilla. The fore part of the gland consists of a cluster of little lobules, each with its own separate duct—the ducts of Walther. They open in a line on the floor of the mouth, on the sublingual ridge.

The **arteries** are derived from the sublingual and submental, with their corresponding veins.

The **nerves** are derived from the gustatory (through the submandibular ganglion) and from the sympathetic.

THE PHARYNX

The **pharynx** is placed behind the nose and mouth, and extends from the base of the skull to the lower part of the cricoid cartilage opposite the sixth cervical vertebra. The soft palate projects into it from the front, dividing it into a **nasal portion** above, and a **buccal portion** below.

The openings of the two posterior nares which are in front, and the orifices of the two Eustachian tubes, one on each side, open into the naso-pharynx; whilst into the buccal portion below the velum are the single openings of the mouth in front, and the larynx and œsophagus below.

Thus there are seven openings leading into its cavity.

It measures from above downwards about four and a half inches (11·3 cm.). It is flattened from before backwards, so that the cavity in this direction is extremely contracted, its mucous membrane, especially above, being thrown into numerous folds and recesses; whilst below the cavity becomes entirely obliterated, and its anterior and posterior walls, except during the act of swallowing, are in actual contact. It is widest opposite the cornua of the hyoid bone, and narrowest below where it passes into the œsophagus.

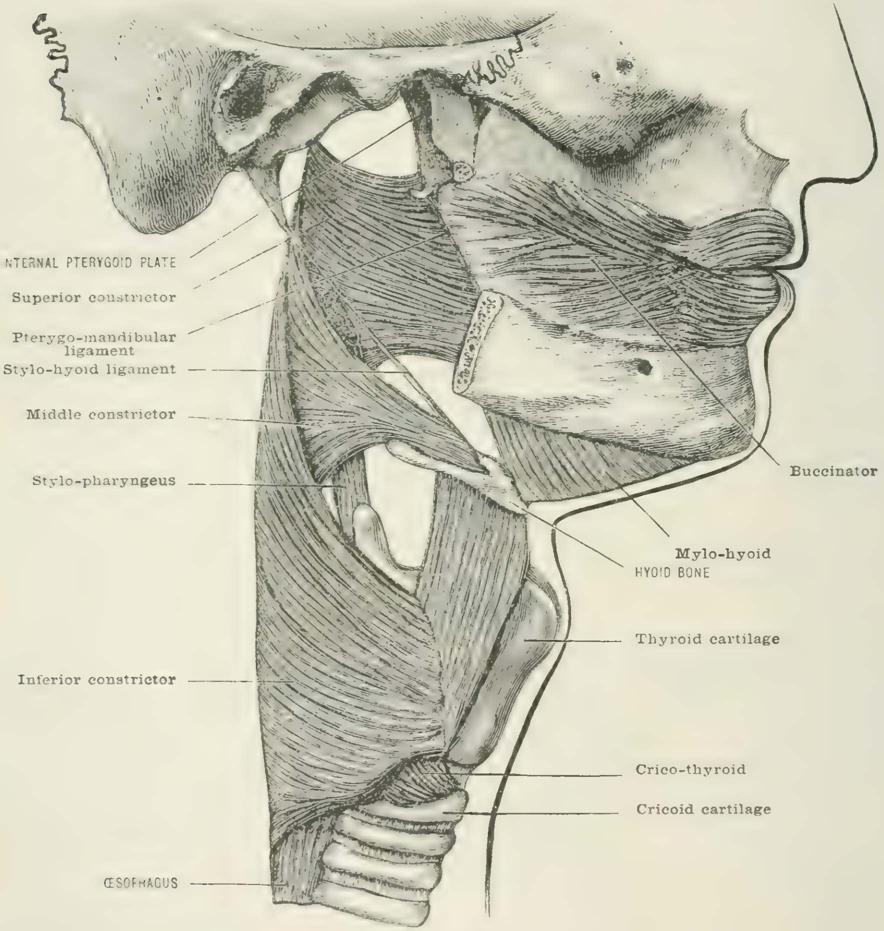
The **pharyngeal walls** are composed of a fibrous coat, the pharyngeal aponeurosis, lined by a mucous membrane, and surrounded externally by muscular layers invested by a delicate areolar sheath which lies beneath the stronger post-pharyngeal fascia.

The **pharyngeal aponeurosis** is well marked above, but below it loses its density and gradually disappears as a definite structure. Above, it is attached to the basi-occipital bone in front of the pharyngeal tubercle. Its attachment may be traced outwards to the apex of the petrous portion of the temporal bone, and thence to the Eustachian tube and internal pterygoid plate.

It descends along the pterygo-maxillary ligament to the posterior of the mylo-hyoid ridge of the lower jaw and passes thence along the side of the tongue to the hyoid bone and larynx.

The **mucous membrane** of the pharynx is continuous with the several cavities which open into it. It is closely adherent to the base of the skull, thick and spongy and dark in colour. It becomes thinner where it approaches the openings of the posterior nares and Eustachian tubes, and below it is paler and folded longitudinally. Lymphoid follicles and numerous racemose glands exist throughout the mucous membrane.

Fig. 559a.—The Muscles of the Pharynx.


NTERNAL PTERYGOID PLATE
Superior constrictor
Pterygo-mandibular ligament
Stylo-hyoid ligament
Middle constrictor
Stylo-pharyngeus
Inferior constrictor
ŒSOPHAGUS
Buccinator
Mylo-hyoid
HYOID BONE
Thyroid cartilage
Crico-thyroid
Cricoid cartilage

The epithelium is ciliated and columnar in the naso-pharynx, but becomes stratified and scaly in the lower portion.

Muscles.—The **muscular coat** consists of the three **constrictor muscles,** with additional fibres derived from the **stylo-** and **palato-pharyngei muscles.**

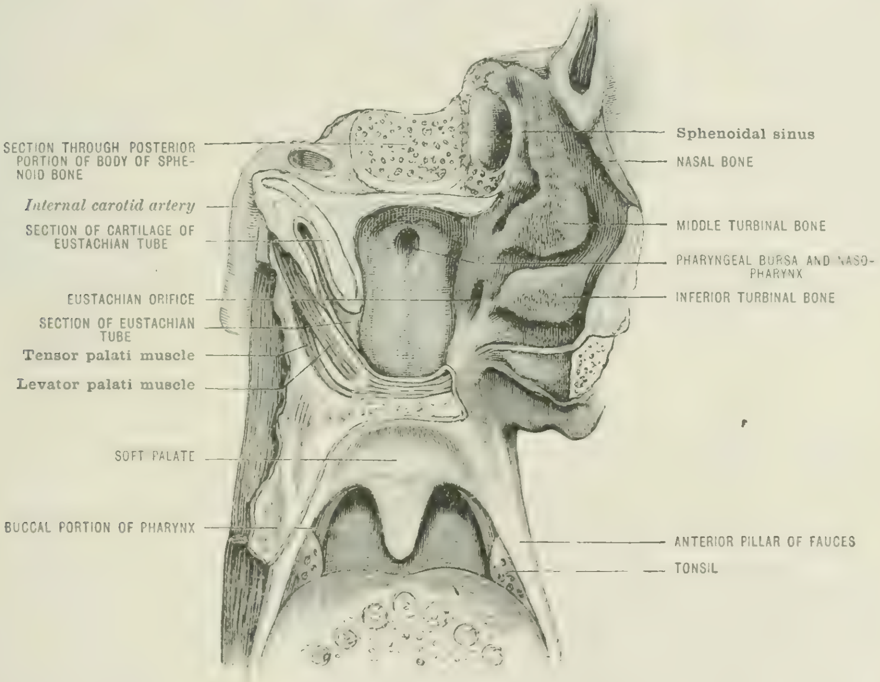
The **inferior constrictor** is thick and strong. It arises from the thyroid cartilage immediately behind the oblique line and superior tubercle, and also from the inferior cornu and the side of the cricoid cartilage, behind the crico-thyroid muscle (fig. 524). The fibres spread backwards and inwards, the lowest horizontally, whilst those above ascend more and more obliquely, and are inserted into the fibrous raphe of the pharynx. Some of the lowest fibres are continuous with the muscular fibres of the œsophagus, and the upper overlap the middle constrictor (fig. 559A).

Near the upper border the superior laryngeal nerve and artery pierce the thyro-hyoid membrane to reach the larynx. The recurrent laryngeal nerve ascends beneath the lower border immediately behind the crico-thyroid articulation.

The **middle constrictor** is a fan-shaped muscle which *arises* from the lesser cornu of the hyoid bone, the whole length of the greater cornu, and from the stylo-hyoid ligament. The diverging fibres are inserted into the median raphe, and blend with those of the opposite side. The lower fibres of the muscle descend beneath the inferior constrictor to the lower part of the pharynx; the upper overlap the superior constrictor, and reach the basilar process of the occipital bone; whilst the middle fibres run transversely (fig. 559A).

The glosso-pharyngeal nerve passes downwards above its upper border, the stylo-pharyngeus is inserted between it and the superior constrictor, and near its origin it is overlapped by the hyo-glossus and crossed by the lingual artery.

FIG. 560.—SECTION SHOWING THE POSTERIOR WALL OF THE PHARYNX, WITH THE PHARYNGEAL BURSA, FAUCES, ETC.


SECTION THROUGH POSTERIOR PORTION OF BODY OF SPHENOID BONE
Internal carotid artery
SECTION OF CARTILAGE OF EUSTACHIAN TUBE
EUSTACHIAN ORIFICE
SECTION OF EUSTACHIAN TUBE
Tensor palati muscle
Levator palati muscle
SOFT PALATE
BUCCAL PORTION OF PHARYNX
Sphenoidal sinus
NASAL BONE
MIDDLE TURBINAL BONE
PHARYNGEAL BURSA AND NASO-PHARYNX
INFERIOR TURBINAL BONE
ANTERIOR PILLAR OF FAUCES
TONSIL

The **superior constrictor** is quadrilateral in shape, pale, and thin (fig. 559A). It arises from the lower third of the hinder edge of the internal pterygoid plate and its hamular process, from the pterygo-mandibular ligament, from the posterior fifth of the mylo-hyoid ridge of the mandible, and from the side of the tongue. The fibres pass backwards to be inserted into the median raphe, the highest reaching the pharyngeal spine. The Eustachian tube and the levator palati muscle are placed above the superior arched border, and the space between this and the basilar process, devoid of muscular fibres, is strengthened by the pharyngeal aponeurosis. It is semilunar in shape, and named the **sinus of Morgagni.**

The **stylo-pharyngeus** arises from the base of the styloid process internally. It passes downwards and inwards to reach the pharynx between the superior and middle constrictors. Its fibres spread out as it descends beneath the mucous membrane. At the lower border of the superior constrictor some of its fibres join fibres of the palato-pharyngeus and are inserted into the posterior border of the thyroid cartilage (fig. 559A); the rest blend with the constrictors.

The **palato-pharyngeus** is described with the muscles of the soft palate.

The muscular coat of the pharynx is supplied by the pharyngeal plexus and the external and recurrent laryngeal nerves. The stylo-pharyngeus is supplied by the glosso-pharyngeal nerve.

Relations.—The pharynx is loosely connected by areolar tissue with the prevertebral fascia, the longus colli, and the rectus capitis anticus major muscles, and vertebral column. Laterally, it is in relation with the styloid process and its muscles, the ninth, tenth, and eleventh cranial nerves, the superior laryngeal nerve and its internal and external laryngeal branches, the parotid and thyroid glands, the sheath of the carotid vessels, the pharyngeal plexus of nerves, the ascending pharyngeal artery, and the ascending palatine branch of the facial artery; above, it is separated from the ramus of the mandible and internal pterygoid muscle by a cellular interval; and beneath its investing fascia there is a plexus of veins.

The **interior of the pharynx,** viewed from behind, presents the seven openings already named. At its upper and back part the mucous membrane forms a rounded projection which corresponds to the anterior recti muscles, and on each side of this it sinks backwards, beneath the tip of the petrous portion of the temporal bone, and behind the Eustachian tube, to form a *cul-de-sac* known as the **pharyngeal recess,** or fossa of Rosenmüller.

In the roof of the cavity just below the body of the occipital bone and in the middle line, the mucous membrane dips into a little pouch with a contracted orifice, the **pharyngeal bursa,** which is easily demonstrated in the fœtus and young child, but commonly entirely disappears in the adult.

Embedded in the roof of the pharynx, in front of the pharyngeal bursa, and between the orifices of the Eustachian tubes, there is a collection of lymphoid follicles which is known as the pharyngeal tonsil, or Luschka's tonsil. This portion of the naso-pharynx is exceedingly liable to become swollen and chronically thickened in naso-pharyngeal catarrh.

THE ŒSOPHAGUS

The **œsophagus** is that portion of the alimentary tract which extends between the pharynx and the stomach. It is more constricted than the rest of the canal, being narrowest at its commencement opposite the sixth cervical vertebra and lower border of the cricoid cartilage. It is again somewhat contracted in its passage through the diaphragm, which is opposite the upper border of the eleventh thoracic vertebra. It is nine or ten inches (25 cm.) in length, and in its course downwards follows the curves of the vertebral column, until it finally passes forwards in front of, and slightly to the left of the aorta to gain the œsophageal opening in the diaphragm. In addition to these curves it presents two lateral curvatures, one convex towards the left side at the root of the neck and in the upper part of the thorax, and the other concave towards the left in the lower part of the thorax where it leaves the vertebral column. It lies in the middle line at its commencement opposite the sixth cervical vertebra, and again, at a lower level, opposite the fifth thoracic vertebra.

Relations in the neck.—The œsophagus has **in front** of it the trachea, the posterior portion of the left lateral lobe of the thyroid gland, and the left recurrent laryngeal nerve, branches of the inferior thyroid artery and the carotid sheath. **Behind,** it rests upon the vertebral column, the left longus colli muscle, and prevertebral fascia.

On its right side are placed the right carotid and right recurrent nerve; and **on the left side** the left inferior thyroid vessels, left carotid artery, left subclavian, and the thoracic duct. The recurrent nerves pass upwards on each side to gain the interval between the trachea and œsophagus. The left nerve, as already described, lies in front of the tube, and the right at some little distance from it.

In the thorax the œsophagus descends through the superior and the posterior mediastina. In the superior mediastinum its anterior relations are the trachea, with the deep cardiac plexus in front of its bifurcation, the left subclavian and carotid arteries crossing its left border obliquely, the left recurrent laryngeal nerve and the arch of the aorta. To the left are the left carotid and subclavian arteries, the end of the arch of the aorta, and the left pleural sac. To the right it is in relation with the right vagus nerve and the right pleural sac. Behind, it rests upon the vertebral column, the left longus colli muscle, and it overlaps the thoracic duct. As it enters the posterior mediastinum it passes behind the left bronchus and the right pulmonary artery, resting posteriorly on the vertebral column and thoracic duct. In the posterior mediastinum it has in front of it the pericardium, which separates it from the left auricle of the heart and a portion of diaphragm; it rests upon the vertebral column, the vena azygos minor, superior and inferior, the right aortic intercostal arteries, and the thoracic duct. To the right is the right pleural sac, the vena azygos major, which it partly overlaps, and below the thoracic duct. To the left in the upper part is the descending thoracic aorta, and below the left pleural sac is separated from it by a little loose areolar tissue. It is surrounded by the œsophageal plexus formed by the vagi nerves, and as they emerge from the lower part of the plexus the left vagus lies in front of the œsophagus and the right vagus behind.

In the abdomen the œsophagus lies in the epigastric region. In front of it is the left lobe of the liver. To the left the left lobe of the liver and the fundus of the stomach. To the right the Spigelian lobe of the liver, and behind the decussating fibres of the crura of the diaphragm and the left inferior phrenic artery.

The arterial supply of the œsophagus is derived from the inferior thyroid, the œsophageal branches of the aorta, the intercostals, the inferior phrenic, and the coronary arteries.

The veins accompany the arteries.

The nerves are filaments of the spinal accessory which pass to it by the vagus, and the recurrent laryngeal nerves.

After death the gullet is somewhat flattened from before backwards, but it is more rounded during life. It is closed except during the passage of food, etc.

Structure.—The wall of the œsophagus is composed of three coats—**muscular, submucous,** and **mucous.** It is surrounded with elastic cellular tissue, loosely connecting it with the neighbouring structures, and freely permitting its distension.

The **muscular coat** is thick, red, and consists of striped muscular fibres in its upper third or more. It is made up of two distinct layers.

The **longitudinal fibres** commence as three flattened bands; a strong anterior arising from the ridge on the back of the cricoid cartilage (fig. 526), and two lateral bands which blend with the fibres of the pharynx. These all unite into a continuous layer which passes below into the muscular coat of the stomach. Several accessory bands have been described, connected with the trachea, left bronchus, pericardium, and left pleura.

The **circular fibres** are continuous above with the inferior constrictor, and below with the oblique fibres of the stomach; they form a uniform layer which becomes somewhat obliquely disposed towards the middle of the gullet.

The **submucous coat** loosely connects the inner mucous and outer muscular coats. It is the seat of numerous racemose glands whose ducts open on the surface of the mucous membrane.

The **mucous coat** is thick, reddish above, paler below, and deeply folded longitudinally. It presents numerous papillæ and contains racemose glands. It is covered by a stratified squamous epithelium.

THE ABDOMINAL VISCERA

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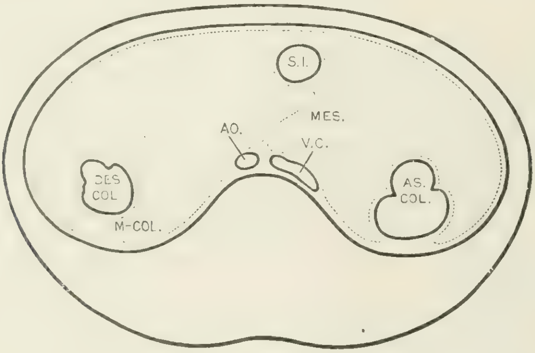
THE PERITONEUM

Its general character.—The **peritoneum** is a thin and delicate serous membrane which lines the cavity of the abdomen from the diaphragm to the pelvic floor, and invests or covers to a varying extent the viscera which that cavity contains. Viewed in its very simplest condition, it may be regarded as a closed sac, the inner surface of which is smooth and perfectly polished, while the outer surface is rough and is attached to the tissues which surround it. Could it be possible for the peritoneum to be removed entire from the body by some process of superhuman dissection, it would appear simply as a huge thin-walled bag.

In the male subject the peritoneum forms actually a closed sac; but in the female its wall exhibits two minute punctures, which correspond to the openings of the Fallopian tubes. That part which lines the walls of the abdomen is termed the parietal peritoneum; that which is reflected on to the viscera is the visceral peritoneum. The disposition of the peritoneum may first be studied by noting its arrangement as made evident in transverse sections of the abdomen at certain levels.

FIG. 561.—TRANSVERSE SECTION OF THE PERITONEAL SAC AT ABOUT THE LEVEL OF THE UMBILICUS.

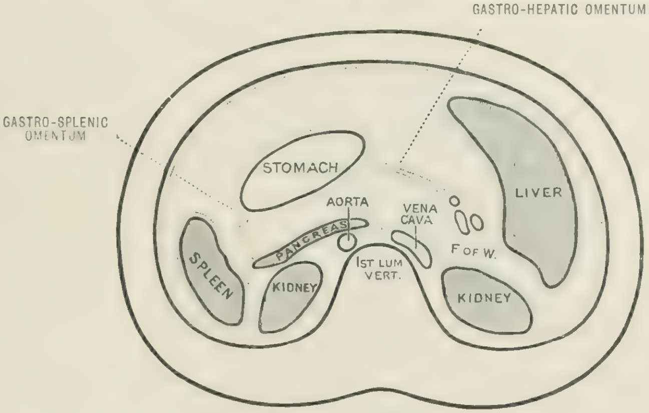


The first section to be described shows the peritoneum in its simplest condition. This is a transverse section through the body, at about the level of the upper surface of the fourth lumbar vertebra, and therefore about the site of the umbilicus (fig. 561). Starting on the inner surface of the anterior abdominal parietes, the peritoneum is seen to cover the transversalis fascia, and indirectly the anterior abdominal muscles; then, passing to the left, it lines the side of the abdomen, until it reaches the descending colon. This it covers, as a rule, in front and on the sides, though occasionally, as shown in the diagram (fig. 561), it forms a meso-colon. Then it passes over the bodies of the vertebræ with the large vessels upon them, and leaves the back of the abdomen to run forward to enclose the termination of the small intestine, returning again to the spine. The two layers thus form the mesentery, having between them the terminal branches of the superior mesenteric vessels. It then passes over the right half of the posterior abdominal wall, covering the ascending colon in front, and at the sides only, unless there be a meso-colon, and then passes on to the side and front of the abdomen to the point from which it was first traced.

In tracing the peritoneum in a section of the body (fig. 562) opposite the stomach, on a level with the first lumbar vertebra, its course becomes more complicated and difficult to follow.

In the section already given the peritoneum as a simple closed sac can be readily conceived; but at the level now exposed the serous membrane has been so introverted that there appears to be two sacs, one leading from the other. The lesser is indeed but a diverticulum or bulging from the greater, and the manner of its formation is explained on page 1002. These two sacs are called the **greater** and the **lesser sacs of the peritoneum.** They communicate through a narrow strait or neck, the foramen of Winslow. The lesser sac or cavity is discovered behind the stomach, so that on first opening the abdomen no trace of it is to be seen. It extends downwards between the layers of the great omentum (though this part of the lesser sac is always obliterated by adhesion in the adult). It extends upwards to the under surface of the liver, and is limited behind by the posterior abdominal wall; and below, behind the great omentum, by the transverse meso-colon. Its disposition on vertical section is shown in fig. 563.

Fig. 562.—Transverse Section of the Abdomen at the Level of the Foramen of Winslow.

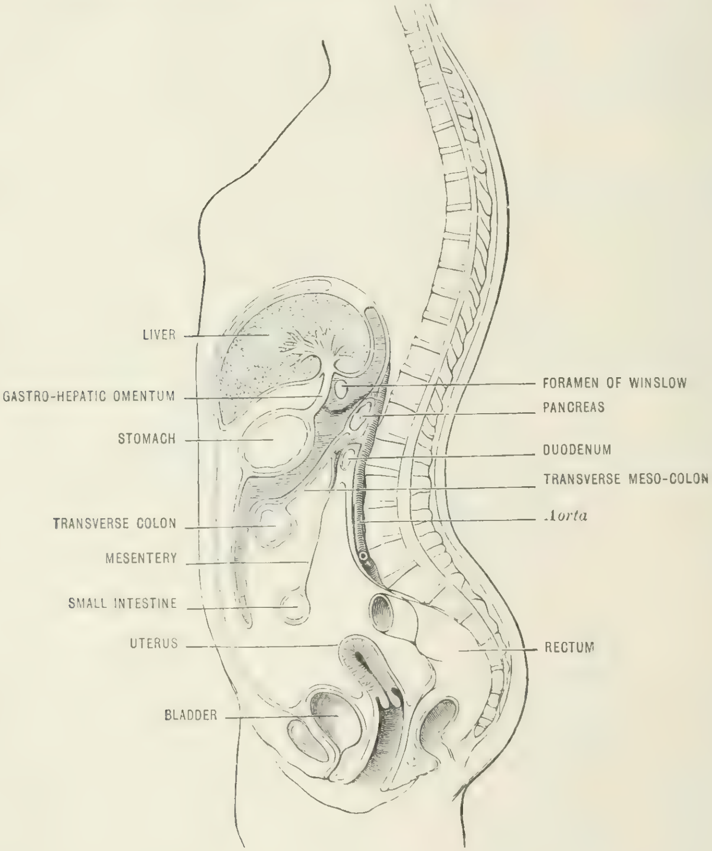


The **foramen of Winslow** is situated just below the liver; it looks forwards and towards the right, and will readily admit one or two fingers. It is bounded above by the caudate lobe of the liver; below, by the duodenum and hepatic vessels; behind, by the vena cava; and in front by the gastro-hepatic or lesser omentum, containing the structures passing to and from the liver.

Starting at the foramen of Winslow, the lesser sac will be found to turn to the left.

If now the peritoneum be viewed in a transverse section of the body at the level named, viz., through the first lumbar vertebra, it will be found that the section has probably passed through the foramen of Winslow (fig. 562). Starting at the front of the abdomen and going to the right, the peritoneum is seen to line the anterior abdominal wall, to pass over the side of the abdomen, and to cover the front of the right kidney; it then extends on to the vena cava, when it becomes a part of the lesser sac; then along the back of the lesser sac, over the aorta and pancreas, which separate it from the vertebral column; next it reaches the anterior of the two internal surfaces of the spleen in front of the hilum. Here it meets with another layer of peritoneum, and helps to form the gastro-splenic omentum. Leaving the spleen, it changes its direction, and runs to the right to the stomach, forming the posterior layer of the gastro-splenic omentum; it covers the posterior surface of the stomach, and leaves its upper border to form the posterior layer of the gastro-hepatic omentum, and then passes upwards and to the right to the liver. In this transverse section, it is only seen passing on the right to the hepatic vessels, where it forms the posterior boundary of the foramen of Winslow. Here it bends sharply round and forms the anterior layer of the gastro-hepatic omentum; and passing to the left reaches the stomach, which it covers in front. It then forms the anterior layer of the gastro-splenic omentum, and once more reaches the spleen. It passes right round the spleen to the back of the hilum, where it is reflected on to the left kidney (fig. 562). Hence the peritoneum passes along the side and front of the abdomen to the point from which it started. In this section the liver is so divided as to appear separated from all connection with the other viscera and the abdominal wall, and to be surrounded by peritoneum.

Fig. 563.—Diagram to show the Peritoneum as seen in a vertical Section. (Allen Thomson.



The course of the peritoneum in a **longitudinal section of the body** will now be considered (fig. 563). Starting at the umbilicus, and passing downwards, the peritoneum is seen to line the anterior abdominal wall. Before reaching the pelvis it covers also the urachus, the deep epigastric arteries, and obliterated hypogastric arteries, which can be seen to form ridges beneath it. For some little way above the os pubis the peritoneum is loosely connected with the abdominal wall, a circumstance which is made use of in supra-pubic cystotomy. Moreover, as the distended bladder rises from the pelvis it can detach the serous membrane to some extent from the anterior parietes. In extreme distension of the bladder the peritoneum may be lifted up for some two inches vertically above the symphysis. On reaching the os pubis it is reflected on to the upper part of the bladder, covering it as far back as the base of the trigone; thence it is reflected on to the rectum, which it covers in front and at the sides on its upper part, or forms for such part a distinct meso-rectum. Between the bladder and rectum it forms the **recto-vesical pouch.** The mouth of this pouch is bounded on either side by a crescentic fold, the plica semilunaris. In the female the peritoneum is reflected from the bladder on to the uterus, which it covers; it then extends so far down in the pelvis as to pass over the upper part of the vagina behind; thence it extends to the rectum. The peritoneum which invests the uterus is reflected laterally to form the broad ligaments. The fold between the vagina and rectum forms the **recto-vaginal pouch,** or pouch of Douglas. The membrane has now been traced back to the spine.

Following it upwards, the sigmoid flexure will be found to be completely covered by peritoneum, a meso-colon attaching the gut to the abdominal wall. As seen in fig. 561, the ascending and descending colon in either loin are covered by peritoneum, as a rule, in front and on the outer sides. A little higher up in the median line the peritoneum passes forwards, to enclose the small intestine, and, returning to the spine, forms the mesentery (fig. 563). It now passes over the third part of the duodenum to the pancreas, from which point it again passes forwards to form the lower layer of the transverse meso-colon. It invests the transverse colon below and partly in front, and then leaves it to pass downwards to take part in the great omentum. Running downwards some distance, it returns and forms the anterior layer of the omentum. On reaching the stomach it goes over the anterior surface, and at the upper border forms the anterior layer of the lesser or gastro-hepatic omentum, which extends between the stomach and the liver. It invests the inferior surface of the liver in front of the transverse fissure, and, turning over its anterior border, covers the upper surface. At the posterior limit of the upper surface it leaves the liver and goes to the diaphragm, forming the superior layer of the coronary ligament. It covers the anterior part of the dome of the diaphragm, and, once more reaching the anterior abdominal wall, can be followed to the umbilicus, where it was first described. On reference to the diagram (fig. 563), the student might be led to suppose that the two sacs as above described are quite separate. This, of course, is not the case; but in a longitudinal section of the body made anywhere to the left of the foramen of Winslow, it is impossible to show the direct connection between the two sacs.

The peritoneum has only been traced in this longitudinal section so far as it concerns the greater sac. It now remains to follow upon the same section such part of the membrane as forms the **lesser sac.** The peritoneum here will be seen to cover the posterior surface of the stomach; and from thence it runs upwards to the liver, forming the posterior layer of the lesser or gastro-hepatic omentum. It reaches the liver behind the transverse fissure. It covers only a part of its posterior surface, and is reflected on to the diaphragm, forming the lower layer of the coronary ligament. It now goes downwards over the hinder part of the dome of the diaphragm to the spine, separated from the latter by the great vessels. On reaching the pancreas it passes forwards, and forms the upper layer of the transverse meso-colon. It then covers the upper half of the transverse colon, and descending, forms the innermost layer of the great omentum. It now ascends, and, arriving at the greater curvature of the stomach, passes on to its posterior wall. At this point its description was commenced. From fig. 562 it will also be evident that the peritoneum forming the lesser sac comes into contact with the spleen, forms one layer of the gastro-splenic omentum, and is in relation with the upper part of the left kidney.

The precise manner in which certain organs—such as the liver, the cæcum, the duodenum, and the kidneys—are invested by peritoneum, is described in the account of those viscera. To such accounts the reader is referred for a description of the many 'ligaments' (such as those of the bladder and liver) which are formed by the peritoneum.

The great omentum.—It will be seen that the great omentum is formed of four layers of peritoneum, though this is quite impossible to demonstrate in an adult, the individual layers having become adherent.

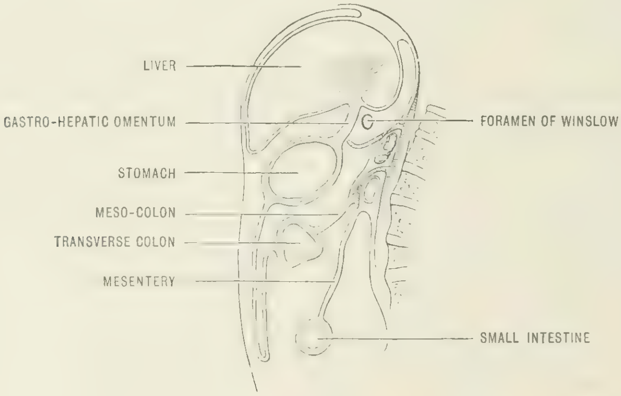
The great omentum acts as a sort of apron, protecting the intestines and providing them with a heat-economising covering of fat. It is nearly quadrilateral in shape, and is variable in extent.

In fig. 564 the great omentum is shown to be connected with the greater curvature of the stomach on the one hand, and the transverse colon on the other. This is the arrangement described in the text. Under certain conditions (as shown in fig. 563) the posterior layer of the great omentum returns to the posterior parietes, and is independent of the transverse meso-colon. This variation is explained in the account of the evolution of the peritoneum (page 1002).

Mr. Lockwood has made some investigations on the lengths of the transverse meso-colon and great omentum in thirty-three cases. In twenty, under the age of forty-five, only one subject had a great omentum long enough to be drawn beyond the pubic spine; in five, the omentum reached as far as the pubes. In the cases beyond forty-five years, it was the exception rather than the rule to find an omentum which could not be pulled beyond the lower limits of the abdomen.

The **lesser** or **gastro-hepatic omentum** consists of a double layer of peritoneum extending between the lesser curvature of the stomach and the transverse fissure of the liver. If the two anterior layers of the great omentum are traced upwards, they are seen to enclose the stomach, and then join together again at the lesser curvature to form the lesser or gastro-hepatic omentum (fig. 563). It is connected above with the transverse fissure of the liver, below with the upper curvature of the stomach; the left extremity encloses the œsophagus; the right border contains the hepatic vessels, and is free, forming the anterior boundary of the foramen of Winslow.

FIG. 564.—DIAGRAM TO SHOW THE PERITONEUM AS SEEN IN VERTICAL SECTION. (Allen Thomson.)



The **gastro-splenic omentum** connects the left extremity of the stomach with the spleen, continuing the layers of peritoneum which enclose the stomach.

The gastro-phrenic and phreno-colic ligaments.—As the peritoneum passes from the diaphragm to the stomach it forms a small fold just to the left of the œsophagus. This is the gastro-phrenic ligament. A stout fold of the membrane also extends from the diaphragm (opposite the tenth and eleventh ribs) to the splenic flexure of the colon, and is known as the phreno-colic or costo-colic ligament.

Subperitoneal connective tissue.—An elaborate account of this tissue has been written by Mr. Anderson and Mr. Makins. According to these observers, 'the subperitoneal and subpleural fasciæ are to be regarded as a portion of a wide system of mesoblastic connective tissue which surrounds the great vessels of the trunk, accompanying these branches from origin to termination, and extending mainly in the form of perivascular sheaths to all parts of the body.'

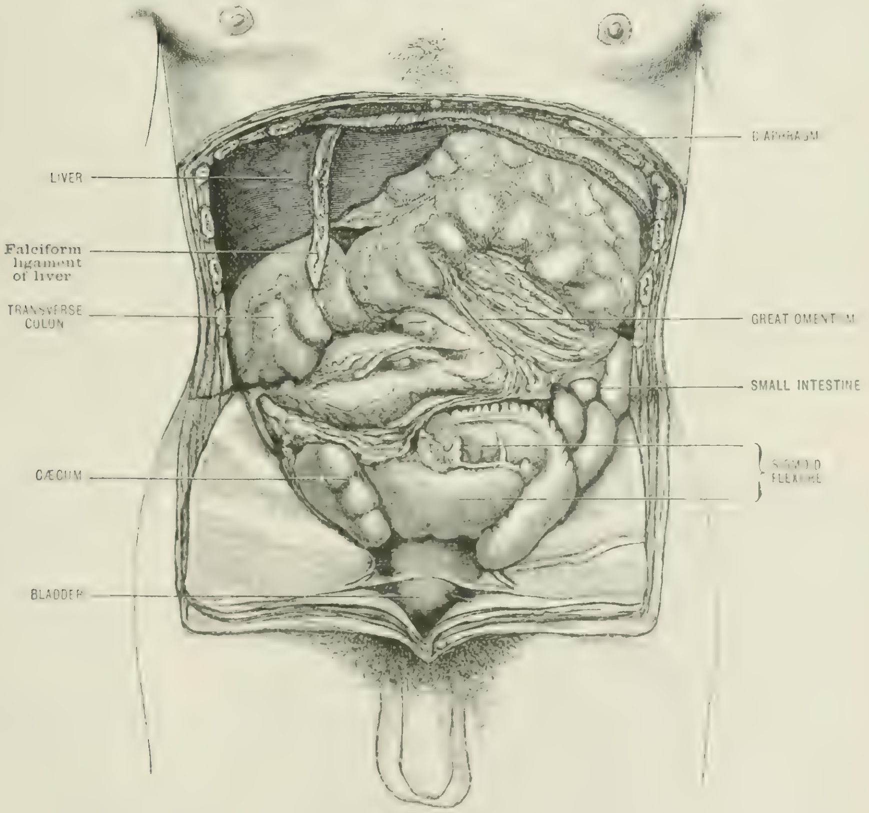
The subperitoneal segment of the tissue they divide into two portions: a parietal layer, closely connected to the wall of the cavity, and visceral lamina which accompany the branches of the aorta to their distribution.

The *parietal layer* is developed chiefly in front of the vertebral column, 'from which point it may be traced as a broad expansion between, and intimately connected with, the peritoneum on the one hand, and the transversalis, diaphragmatic, iliac, obturator, and recto-vesical fasciæ on the other.' It forms a sheath for the large vessels, and is continuous with the vessels outside the abdomen.

The *visceral portion* follows the course of the branches of the aorta, and greatly assists in fixing certain viscera, such as the liver, pancreas, etc., becoming continuous with their connective-tissue tunic. This tissue can be seen passing between the layers of peritoneum to those organs which are connected to the abdominal wall by duplicatures of peritoneum.

For an account of the evolution of the peritoneum, and an explanation of its arrangement in the human body, the student is referred to page 991.

FIG. 565.—THE VISCERA AS SEEN ON FULLY OPENING THE ABDOMEN WITHOUT DISARRANGEMENT OF THE INTERNAL PARTS. (After Sarazin.)



THE ABDOMEN

The **abdomen** properly consists of that part of the body cavity situated between the diaphragm and the pelvis. It is bounded above by the diaphragm; below, by the brim of the true pelvis; behind, by the vertebral column, diaphragm, quadratus lumborum and psoas muscles, and by the posterior portions of the ilia. At the sides it is limited by the anterior parts of the ilia and the hinder segments of the muscles which compose the anterior abdominal wall, viz., the transversalis, internal oblique, and external oblique. In front, besides these muscles, there are the two recti and pyramidales muscles. External to the peritoneum the abdomen is lined by a special layer of fascia.

The abdomen is the largest serous cavity in the body. Its serous membrane is the peritoneum, which, through its various complicated arrangements, is always (with one unimportant exception) a closed sac, so that the viscera are in reality situated outside the enclosure. The principal viscera found in the abdomen are those connected with digestion and the excretion of urine.

On freely laying open an abdomen from the front, the general form of the space is seen to be an irregular hexagon, the sides of which are formed as follows:—The upper two by the margins of the costal cartilages with the ensiform cartilage between; the two lateral sides by the edges of the lateral boundary; and the two lower by the two ligaments of Poupart which meet at the pubes.

In this irregular hexagon the following organs can be observed without disarranging their normal position (fig. 565). Above, on the right side under the costal cartilages, can be seen the liver, which extends from the right across the median line to a point below the left costal cartilages. Below the liver, and lying to the left side, can be seen the anterior surface of the stomach; from the lower border of the stomach the omentum extends downwards, and shining through it can be seen the middle part of the transverse colon. On each side and below the irregularly folded omentum are exposed the coils of the small intestine; in the right iliac fossa a part of the cæcum appears; and in the left iliac fossa a coil of the sigmoid flexure is usually evident.

To the left of the stomach and under cover of the lower ribs of the left side the edge of the spleen may possibly be observed; and just below the edge of the liver, and about the level of the tip of the ninth rib, the gall bladder may be seen. The dome of the urinary bladder may be noticed just behind the symphysis pubis and in the median line. The disposition of the viscera in the fœtus is shown in fig. 578.

THE STOMACH

General description.—The **stomach** is situated in the upper part of the abdominal cavity and to the left side. When empty it is found in the left hypochondrium and left half of the epigastric region. Above it are the liver and diaphragm, while below is the transverse colon. It is somewhat pyriform in outline, with the small end of the figure twisted upward. Its length is about twelve inches, and its width four to five inches. The distance between its two orifices varies from three to six inches. Its average capacity is about five pints (two to three litres). It weighs four ounces and a half.

There are two orifices, two borders, and two surfaces to be noticed. The left, splenic, or cardiac end of the viscus is much expanded, and forms the great *cul-de-sac* or fundus. At the right or pyloric end there is another slighter expansion, called the antrum pylori or small *cul-de-sac* (fig. 566).

The **cardiac orifice**, by which the œsophagus opens into the stomach, is situated about three inches from the left extremity, owing to the bulging to the left of the great *cul-de-sac*. The **pyloric orifice**, or **pylorus**, is situated to the extreme right, and is more anterior in position than the cardiac orifice.

The **pylorus** is produced by a thickening of the visceral walls between the duodenum and stomach. The circular muscular fibres which surround the stomach are here thickened into a strong ring, thus forming a sphincter which can be felt from the outside. The longitudinal fibres pass over the circular fibres, and are not generally supposed to take part in the thickening. The mucous membrane is pushed in by the muscular ring and also thickened. The pyloric opening will hardly admit a sixpence, its fullest diameter being about one-half of an inch

(13 mm.). It is the narrowest part of the digestive canal. There is no such special sphincter apparatus at the cardiac end of the stomach, the œsophagus passing directly into its walls, and becoming wider as it does so. When the stomach is distended the gullet may become a little bent at its junction with the stomach, and the escape of fluid into the œsophagus be thus prevented.

The two **borders** are situated above and below, and run between the two orifices. The upper is known as the lesser curvature, and is about three to five inches long; it is concave along its whole length, except near the pylorus, where it takes part in the antrum pylori (fig. 567). The lower border is called the greater curvature, and is convex except near the right extremity just before the formation of the antrum pylori, where there is a slight depression. It is about four times as long as the upper border.

FIG. 566.—POSTERIOR SURFACE OF THE STOMACH.

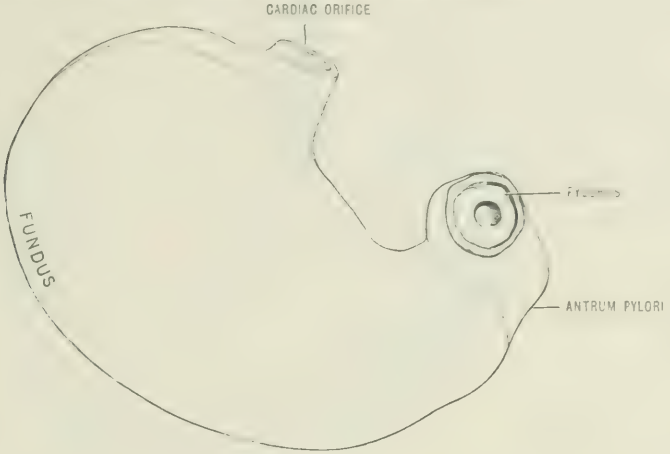
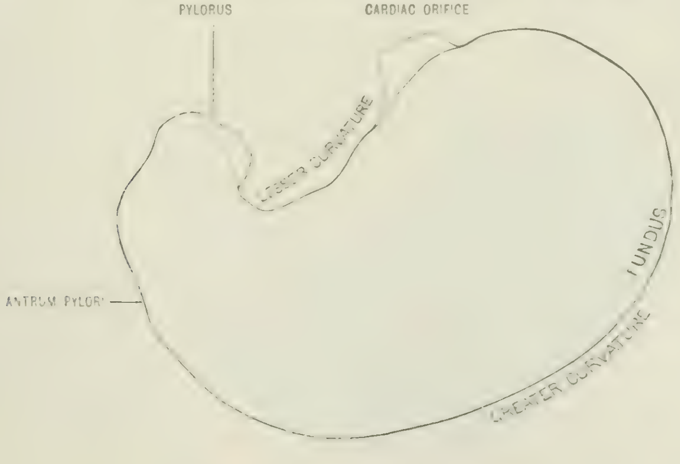


FIG. 567.—ANTERIOR SURFACE OF THE STOMACH.



The two **surfaces** lie between the two borders. They are of equal extent, and are named the anterior and posterior surfaces.

Relations to surrounding parts.—The degree of obliquity of the stomach in its relations to the long axis of the body has been a disputed point, the majority of authorities holding that it lies slightly obliquely from left to right; while a few (Luschka and Lesshaft) maintain that its direction is vertical. In an early period of development the organ is certainly vertical, and in rare instances this position may be maintained throughout life. As a rule, however, the organ is placed obliquely, and lies in the left hypochondriac and epigastric regions (figs. 578, 582, and 583). Its position, under normal conditions, must be liable to much variation.

The *cardiac end*, or fundus, reaches as high as the level of the sixth chondrosternal articulation, being a little above and behind the heart apex. The cardiac orifice is opposite the seventh left costal cartilage, and is about one inch from the sternum. Behind, it is about on the level with the body of the tenth or eleventh dorsal vertebra. The *pylorus* is on a lower level and nearer the surface than the cardiac end, and is opposite a point to the right of the middle line two to three inches below the sterno-xiphoid articulation, on the level of a line drawn between the bony ends of the seventh ribs (fig. 582). Behind, it is on a level with the twelfth thoracic spine (fig. 583). Its position is much influenced by the state of distension of the stomach.

The *posterior surface* of the stomach looks backwards and downwards, lying on the transverse meso-colon, spleen, splenic artery, pancreas, left kidney and supra-renal capsule, and great abdominal vessels (figs. 586, 590).

Above.

Liver, small omentum, diaphragm.

In Front.

(From left to right.)

Diaphragm, abdominal wall, liver.

GENERAL RELATIONS
OF THE
STOMACH

Behind.

Transverse meso-colon, pancreas, crura, solar plexus, great vessels, spleen, left kidney, and capsule.

Below.

Great omentum, transverse colon, gastro-splenic omentum.

The *anterior surface* looks upwards and forwards. Its relations are of importance in connection with the operation of gastrostomy. A certain portion of this surface comes into immediate contact with the abdominal wall; this portion is triangular in shape, is bounded on the right by the edge of the liver, and on the left by the cartilages of the eighth and ninth ribs; and below by a horizontal line passing between the tips of the tenth costal cartilages (fig. 582). Besides the abdominal wall, this surface is covered by the diaphragm and the under surface of the left lobe of the liver (fig. 590).

Relations to the peritoneum.—The stomach is covered by peritoneum in its whole extent, except immediately along the curvatures and upon a small triangular space at the back of the cardiac orifice, where the viscus lies in direct contact with the diaphragm and possibly with the upper part of the left supra-renal capsule. It is enclosed between two layers. These two layers at its upper border or lesser curvature come together to form the lesser omentum, and at the lower border or greater curvature extend downwards, to form the great omentum (figs. 562, 563). At the left of the œsophagus the two layers pass to the diaphragm, forming the gastro-phrenic ligament; and at the fundus they pass on to the spleen, forming the gastro-splenic omentum.

Alteration of position.—When the stomach is empty the surfaces are flat and the pyloric end is situated near the median plane and under cover of the liver. As it distends, it occupies the left dome of the diaphragm and tilts up the heart apex. Moreover, it undergoes some alteration in position. The greater curvature is elevated and carried forwards, the anterior surface is directed upwards, and the posterior downwards, and the pylorus passes some inches to the right. The pyloric orifice, which in the empty stomach looks to the right, is so turned as to look backwards. This rotation about its long axis is influenced by the fixity of the lesser curvature of the organ.

Structure.—The walls of the stomach consist of four coats,—serous, muscular, submucous, and mucous.

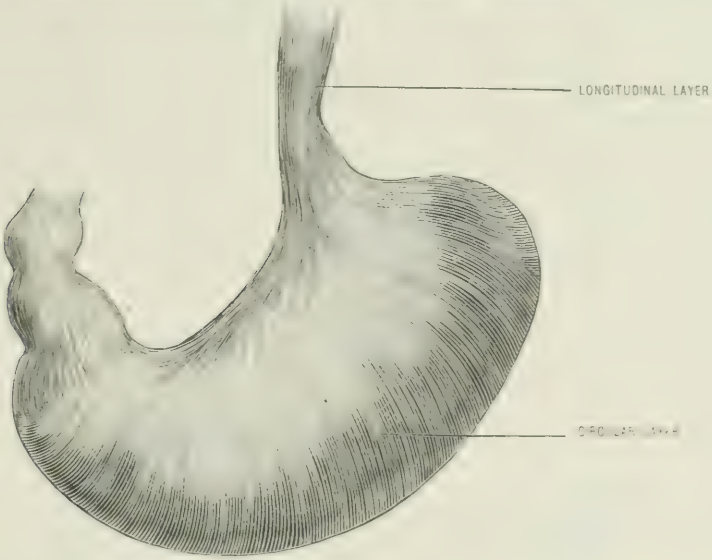


FIG. 568.—MUSCULAR COAT OF THE STOMACH. (Luschka.)

The *external serous coat* is formed by the peritoneum, and has to the naked eye the usual shiny appearance of that membrane.

The *muscular coat* consists of three layers:

A *longitudinal layer* externally, which is continued from similar fibres on the œsophagus, and is thickest along the curvatures, more particularly the lesser. At the pylorus the fibres are more regularly placed round that orifice (fig. 568).

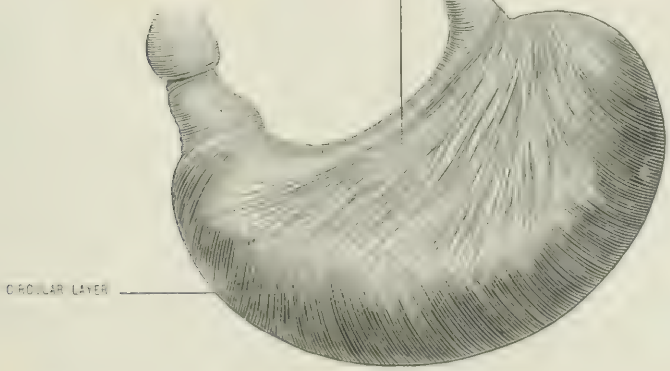


FIG. 569.—MUSCULAR COAT OF THE STOMACH. (Luschka.)

A *circular layer*, which regularly surrounds the whole stomach and becomes much thicker at the pyloric end, where it forms the sphincter. These circular fibres are arranged perpendicularly to the long axis of the stomach (fig. 569).

An *oblique layer*, continuous with the circular fibres of the œsophagus. They pass to the left of the œsophagus towards the great curvature. They unite finally with the circular fibres (fig. 569).

The *submucous coat* is made up of areolar tissue, in which the blood-vessels break up.

The *mucous* or *internal coat* is pink in colour and soft to the touch, and when the stomach is not distended has a rugose appearance. It is covered with columnar epithelium, and with a lens shows the openings of numerous glands. A thin layer of muscular tissue—the *muscularis mucosæ*—supports the mucous membrane externally. The mucous membrane is thickest in the pyloric area and thinnest over the great *cul-de-sac*. In the stomachs of young persons the surface of the stomach may be studded by little elevations due to local accumulations of lymphoid tissue.

Nerves.—The nerves of the stomach are the right and left pneumogastric, the right nerve passing over the posterior surface, and the left over the anterior. The organ is also connected with the sympathetic system by means of the solar plexus.

Blood-supply.—The stomach receives its blood-supply from many branches. From the cœliac axis there is the gastric artery, which runs along the lesser curve from left to right, anastomosing with the pyloric branch of the hepatic. Along the greater curve run the right and left gastro-epiploic arteries, anastomosing at the middle of the border, the left being a branch of the splenic, the right a branch of the hepatic through the gastro-duodenal artery. The stomach also receives branches from the splenic (vasa brevia) at the fundus.

The blood of the stomach is returned into the portal vein. The coronary vein and pyloric vein open separately into the portal vein; the right gastro-epiploic vein opens into the superior mesenteric, the left into the splenic.

Lymphatics.—There is a set of glands lying along the greater and the lesser curvatures, and others at the pyloric and cardiac ends. These are entered by lymphatic vessels beginning in the mucous membrane.

THE INTESTINES

THE SMALL INTESTINE

The **small intestine** is that part of the intestinal canal which lies between the pylorus and the ileo-cæcal valve. It is conveniently divided into three portions: the **duodenum, jejunum,** and **ileum.** It is of the average length in the adult male (between the ages of twenty and fifty) of twenty-two feet six inches. In the female it is longer, the average length being twenty-three feet four inches. The length is independent, in the adult at least, of age, height, or weight. The length may vary in the male from thirty-one feet ten inches to fifteen feet six inches. In the female, from twenty-nine feet four inches to nineteen feet ten inches.

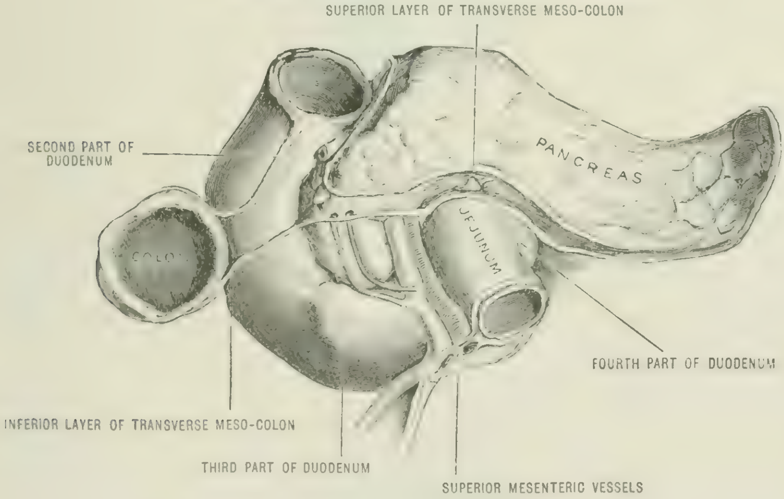
With the exception of the duodenum, the small intestine lies for the most part inside the more fixed portions of the large intestine (figs. 565, 578). It is also, with the exception of the duodenum, connected to the posterior abdominal wall by a process of peritoneum, the *mesentery*. This broad membrane is seen to extend from above downwards, and from left to right from the duodenum above to the ileo-cæcal valve below, enclosing the jejunum and ileum along the whole of their extent (figs. 561, 563, and 599).

The **duodenum**—the first portion of the small intestine—is, unlike the other parts of that bowel, very definite in position and extent. It is that part which is not contained by the mesentery. It is formed from the end of the embryonic fore-gut, and its peculiar position behind the transverse colon is due to the rotation from left to right of the intestine in the fœtus (page 995). It is the most fixed as well as the widest part of the small intestine. It measures one and a half to two inches in diameter, and is about ten inches long. It has been compared in general shape to a horseshoe, though not very aptly, as the one side is so much longer than the other. It is arranged in a curved manner round the pancreas, and readily lends itself to a division into four parts (fig. 577).

The *first part*—the *superior*, or *ascending*—is hardly two inches long. Beginning at the pylorus, and passing upwards and backwards to the right, it ends at the neck of the gall-bladder. It is the most movable of the four portions. It is covered by the two layers of peritoneum which are continued from the stomach, and by these it is completely surrounded in front, but is only covered behind in the vicinity of the pylorus. Above it are found the liver (quadrate lobe) and gall bladder. The gut itself forms the lower boundary of the foramen of Winslow. Below it is the pancreas; and behind are the common bile-duct, hepatic vessels and portal vein.

The *second part*—the *descending portion*—not quite three inches long, extends from the neck of the gall bladder to the third lumbar vertebra, a short bend marking the separation between the first and second parts. This part is covered by peritoneum in front only, the membrane being derived from a continuation of the superior layer of the transverse meso-colon (fig. 570).

FIG. 570.—THE DUODENUM FROM IN FRONT.


SUPERIOR LAYER OF TRANSVERSE MESO-COLON
SECOND PART OF DUODENUM
PANCREAS
COLON
JEJUNUM
FOURTH PART OF DUODENUM
INFERIOR LAYER OF TRANSVERSE MESO-COLON
THIRD PART OF DUODENUM
SUPERIOR MESENTERIC VESSELS

It is more fixed than the first portion. It is in relation in front with the transverse colon and meso-colon. On its left side is the pancreas (fig. 577), and the common bile-duct a little more posteriorly. The loop formed by the pancreatico-duodenal arteries runs also along the left margin of this part of the bowel.

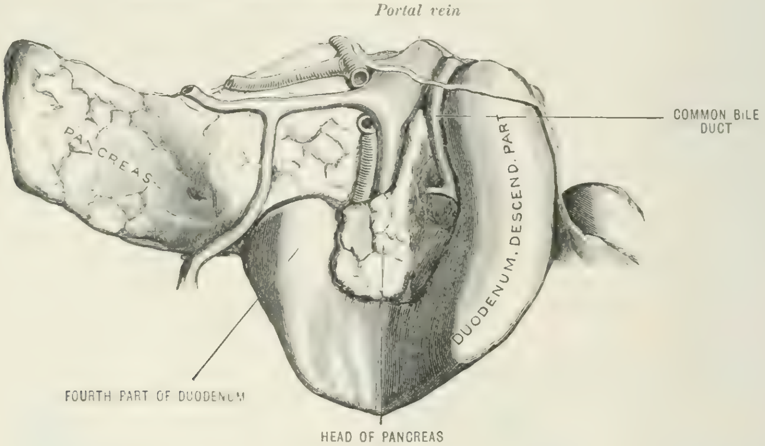
Behind lie the right kidney and the renal vessels and vena cava (fig. 590).

Some of the muscular fibres of this part of the duodenum are said to be continuous with the lobules of the pancreas. Into this segment of the bowel, at its inner and back part and some four inches from the pylorus the common bile-duct and pancreatic duct enter (figs. 571, 586, and 587).

The *third part*, or *transverse portion*, is the longest, being about five inches long. It extends from the body of the third lumbar vertebra on the right side, and passes obliquely across the spine to the upper part of the left side, ascending a little on its way. In front of the third part of the duodenum is found the lower layer of the transverse meso-colon. The superior mesenteric vessels cross this part of the bowel, running between it and the pancreas to reach the mesentery (fig. 570). Along the upper border runs the inferior pancreatico-duodenal artery. The gut is in relation above with the pancreas and superior mesenteric artery. Behind are the vena cava, aorta, and crura of the diaphragm (figs. 571, 577). It is the most fixed portion of the duodenum, and is covered in front only by peritoneum.

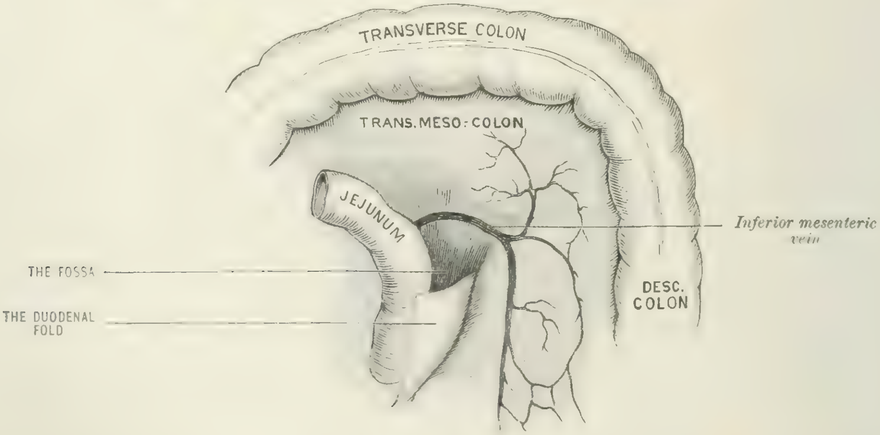
The *fourth part* of the duodenum, or *second ascending* portion, ascends vertically by the left side of the spine. This vertical portion—which is covered entirely in front and partly at the sides by peritoneum—is at least an inch in length (figs. 570, 571, and 572). The end of the duodenum is very firmly fixed in its place by the *musculus suspensorius duodeni.* This name has been given to a fibrous band that contains, according to Treitz, some plain muscular fibres, and that descends to the vertical part of the duodenum from the left crus of the diaphragm and the tissues about the cœliac axis.

Fig. 571.—The Duodenum from behind.


Portal vein
COMMON BILE DUCT
PANCREAS
DUODENUM. DESCEND. PART
FOURTH PART OF DUODENUM
HEAD OF PANCREAS

Mr. Lockwood points out that this band is continued on, after being inserted into the duodenum, between the layers of the mesentery. He suggests the name of the 'suspensory muscle of the duodenum and mesentery,' and says, 'together with the other constituents of the root of the mesentery, it forms a band of considerable strength, sufficient not only to support the weight of the intestines and mesentery, but also to resist the pressure of the descent of the diaphragm.'

Fig. 572.—The Fossa Duodeno-jejunalis. (Treves.)


TRANSVERSE COLON
TRANS.MESO-COLON
JEJUNUM
Inferior mesenteric vein
THE FOSSA
THE DUODENAL FOLD
DESC. COLON

In connection with the termination of the duodenum may be mentioned the **fossa duodeno-jejunalis.** It is formed as a pouch behind a fold of peritoneum. This fold runs from the parietal peritoneum, just to the left of the terminal or fourth part of the duodenum, and is attached in a vertical line to the anterior surface of this portion of the bowel. It is of interest as being the seat of origin of a retroperitoneal hernia.

The fold forming the fossa is the remains of the 'duodenal fold,' modified by growth and displaced by the process of unequal development in the intestinal canal (page 1003 and figs. 605, 606). The pocket, or fossa, is of triangular outline, with the base or orifice upwards. Its apex extends below the last bend of the duodenum (fig. 572). The capacity of the fossa varies. In well-marked specimens it will lodge the thumb up to the first joint. It is actually occupied by the duodeno-jejunal junction or bend. Out of one hundred bodies examined, I found this fossa in forty-eight examples.

Jejunum and ileum.—There is no unvarying method in the arrangement of the individual coils of the small intestine.

In the majority of adult bodies the small intestine is disposed in an irregularly curved manner from left to right. The gut, starting from the duodenum, will first occupy the contiguous parts of the left side of the epigastric and umbilical regions; the coils then fill some part of the left hypochondriac and lumbar regions; they now commonly descend into the pelvis, reappearing in the left iliac quarter, and then occupy, in order, the hypogastric, lower umbilical, right lumbar, and right iliac regions. Before reaching the last situation they commonly descend again into the pelvis.

In many instances no kind of methodical arrangement is apparent. The coils of small intestine most usually found in the pelvis belong to the terminal part of the ileum, and to that part of the intestine that has the longest mesentery—the part, namely, that extends between two points, respectively six and eleven feet from the end of the duodenum. In five out of one hundred cases examined, the coils were arranged in an exactly reverse manner to that just described.

The **jejunum** (*jejunus*, empty).—The jejunum is the name given to the upper two-fifths of the small intestine below the duodenum.

The term **ileum** (*εἰλεῖν*, to twist) is applied to the last three-fifths of the bowel. The ileum ends at the ileo-cæcal valve. The coils formed by the jejunum and ileum are very movable, are completely invested by peritoneum, and are supported and attached to the posterior parietes by the extensive membrane known as the mesentery.

The intestine alters gradually in character from above downwards. If a segment from the middle of the jejunum be compared with a portion of the middle ileum, the following differences would be noted. The diameter of the jejunum is about an inch and a half, that of the ileum one and a quarter. The jejunum has thicker walls, is more vascular, and is provided with a more complex mucous membrane.

Meckel's diverticulum.—From one to three feet from the end of the ileum is sometimes seen a diverticulum, or blind tube or cord, coming off from the free margin of the bowel. This is Meckel's diverticulum, and represents the remains of the vitello-intestinal duct (page 994).

The mesentery.—The mesentery extends from the end of the duodenum to the ileo-cæcal junction. It envelopes and supports the ileum and jejunum. Its upper or right layer is continuous with the under layer of the transverse meso-colon and with the peritoneum that invests the ascending colon. Its lower or left layer joins with the serous membrane that encloses the descending colon and that forms the sigmoid mesentery (fig. 561).

The point at which the mesentery is attached above is on a level with the lower border of the pancreas and just to the left of the vertebral bodies. From this point the insertion of the mesentery follows an oblique line that runs downwards and to the right, crossing the great vessels, and ending in some part of the iliac fossa (fig. 599). In the absence of an ascending meso-colon (the normal condition) the peritoneum that covers the cæcum is reflected from the hinder surface of that part of the bowel on to the posterior parietes: at this reflexion the mesentery ends. If an ascending meso-colon exists, the mesentery terminates by joining it. The parietal attachment of the mesentery measures, as a rule, about six inches (fig. 599). The length of the mesentery from the spine to the intestine varies in different parts of the canal; its average length may be taken as between eight and nine inches. It soon attains its full length, and within one foot of the end of the duodenum is already six inches in length.

The ordinary type of mesentery conforms to the figure of half a circle, but the membrane is liable to considerable variation. It is not uncommon to find the mesentery maintaining a considerable length up nearly to the end of the ileum.

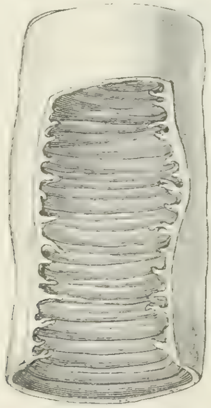
Structure of the small intestine.—Its coats are four in number—viz., serous, muscular, areolar, and mucous. The intestine receives its *serous* covering from the peritoneum, and, with the exception of certain parts of the duodenum which have been described, it is covered entirely by it, save only where the layers leave it behind to form the mesentery. The line of attachment of the mesentery marks the attached border of the small intestine.

The *muscular coat* is divided into an external longitudinal layer and an internal circular, the circular being the thicker of the two. Both layers are uniform around the bowel, and become thinner as the cæcum is approached.

The *areolar* or *submucous coat* consists of areolar tissue connecting the muscular and mucous tunics. A thin layer of muscular tissue separates the mucous membrane from the areolar coat (muscularis mucosæ).

The *mucous coat*, thicker at the upper part than the lower part, is lined throughout with columnar epithelium and is very vascular. The whole surface is covered with minute processes called *villi*: these give the membrane a finely flocculent appearance, which has been compared to the pile of velvet. They are largest and most numerous in the duodenum and jejunum, and become gradually shorter, smaller, and fewer on the ileum. Besides the villi are certain large folds or valvular flaps: these are the *valvulæ conniventes*. They are permanent crescentic folds of mucous membrane set transversely to the long axis of the intestine. The majority extend from one-half to two-thirds of the distance round the lumen (fig. 573). The largest are more than two inches long, and about one-third of an inch wide. Some of the valvulæ conniventes form complete circles and others spirals. These mucous folds do not exist at the beginning of the duodenum. They are very large just below the entrance of the bile-duct, and remain conspicuous until the middle of the jejunum is reached. They then become smaller, and gradually disappear at the lower part of the ileum.

Fig. 573.—Portion of the Small Intestine, laid open to show the Valvulæ Conniventes. (Brinton.)



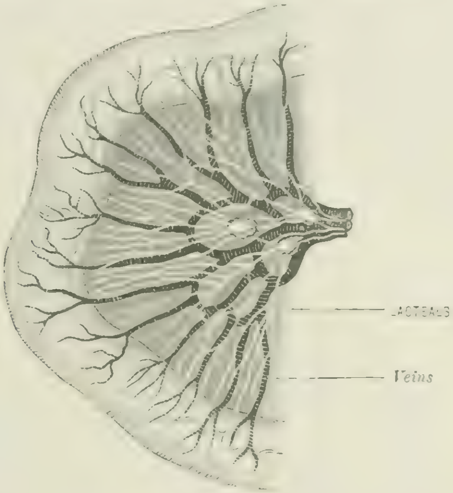
Scattered over the whole of the mucous membrane of the small intestine are numerous minute soft rounded bodies composed of retiform tissue. These are the so-called *solitary glands*.

Certain patches, called *Peyer's patches*, are found in the lower ileum. They are oval, are from one-half to three inches in length, and about one inch in breadth, and are placed in the long axis of the bowel along a line most remote from the mesentery. They are made up of an aggregation of solitary glands.

A number of closely set acino-tubular glands, called *Brunner's glands*, may be exposed by dissection in the first part of the duodenum.

Blood-supply of the small intestine.—The small intestine receives its blood from the superior mesenteric artery, and a branch coming indirectly from the hepatic, the superior pancreatico-duodenal. The superior mesenteric runs between the layers of the mesentery, and gives off about twelve or fifteen branches, running downwards and to the left (vasa intestini tenuis), which break up and form a series of arches, finally encircling the intestine as small branches. It also gives off a small branch at the beginning, the inferior pancreatico-duodenal, which, with the superior pancreatico-duodenal, forms an arch, which lies in the concavity of the duodenum and supplies it. The blood is returned by means of the superior mesenteric vein, which with the splenic vein forms the portal (fig. 574).

FIG. 574.—VESSELS OF THE SMALL INTESTINE.



The **lymphatics** form a continuous series, which is divided into two sets—viz., that of the mucous membrane and that of the muscular coat. The lymph-vessels of both sets form a copious plexus and end in the mesenteric lacteals (fig. 574).

The nerves.—The small intestine is supplied by means of the superior mesenteric plexus, which is continuous with the lower part of the solar plexus. The branches follow the blood-vessels, and finally form two plexuses: one (Auerbach's) which lies between the muscular coats; and another (Meissner's) in the submucous coat.

THE LARGE INTESTINE

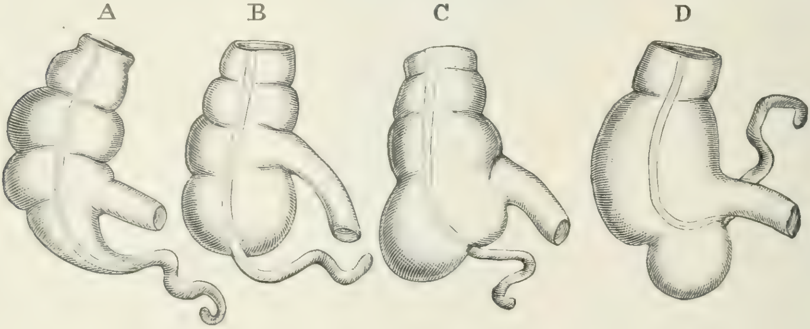
The **large intestine** is that part of the alimentary canal which extends between the ileum and the anus. It is divided into the following parts: Cæcum, ascending, transverse, and descending colon, sigmoid flexure, and rectum. It is so arranged as to surround the small intestine, making a circuit round the abdominal cavity from right to left (fig. 565). The *cæcum* lies in the right iliac fossa; thence the colon passes vertically upwards on the right side (*ascending colon*) until the liver is reached. Here it forms a more or less rectangular bend (hepatic flexure), and then passes transversely across the belly (*transverse colon*) below the stomach. It then reaches the splenic area, where it makes a second sharp bend (splenic flexure), and, passing vertically downwards on the left side (*descending colon*), reaches the left iliac fossa. At this point it forms the loop of the *sigmoid flexure*, and finally passes through the pelvis as the rectum (fig. 577). It is much larger in diameter than the small intestine, and has not the same general convoluted arrangement. Leaving out of consideration the dilated portion of the rectum, it is wider at the beginning than at the end. It varies in width at different parts from two and a half to one and a quarter inches. The length from the root of the appendix or tip of the cæcum to the point where the meso-rectum ends is, in the male, about four feet eight inches, and in the female about four feet six inches.

The extremes found in a number of cases, were for both sexes respectively, six feet six inches, and three feet three inches.

The large intestine, in all parts except the rectum, has a peculiar arrangement of its walls, which gives it a very different appearance from the small intestine. It is *sacculated*, and the sacculation is produced by the gut having to adopt its length to three shorter muscular bands which run the course of the intestine. These bands, which are about 12 mm. wide and 1 mm. thick, are really the longitudinal fibres of the muscular wall, which are chiefly collected at three parts (fig. 575). One band is situated *posteriorly* on the attached border, another runs *anteriorly*, and the third is situated on the *inner* side of the ascending and descending colon, and on the lower border of the transverse colon. All these bands start at the vermiform appendix, and are lost on the rectum. Along the whole length of the large intestine, except the lower part of the rectum, are certain small appendages (*appendices epiploicæ*), seen mostly along the line of the inner muscular band. They are pouches of peritoneum containing fat.

The cæcum, or caput coli.—The cæcum is a *cul-de-sac* forming the first part of the large intestine. It is defined as that part of the colon which is situated below the entrance of the ileum. Its breadth is about three inches, and its length about two and a half inches.

Fig. 575.—The Four Types of Cæcum. (Treves.)



It lies in the right iliac fossa, and is usually situated upon the psoas muscle, and so placed that its apex or lowest point is just projecting beyond the inner border of that inner muscle (figs. 565, 577). It is entirely enveloped in peritoneum, and is free in the abdominal cavity. The apex of the cæcum usually corresponds with a point a little to the inner side of the middle of Poupart's ligament. Less frequently the cæcum will be found to be in relation with the iliacus muscle only; or the bulk of the caput will lie upon that muscle, while the apex rests upon the psoas. In a number of cases the cæcum is entirely clear of both psoas and iliacus muscles, and hangs over the pelvic brim, or is lodged entirely within the pelvic cavity. Some part of the cæcum may pass even to the left of the median line of the body.

This part of the colon is liable to considerable variation.

Its *variations* may be described under *four types:*

1. The fœtal type is conical in shape, the appendix arising from the apex. This process is a continuation of the long axis of the colon. The three muscular bands which meet at the appendix are nearly at equal distances apart (fig. 575, A.).

2. The second form is more quadrilateral in shape than the last; the three bands retain their relative positions; the appendix appears between two bulging sacculi, instead of at the summit of a cone (fig. 575, B.).

3. In the third type, that part of the caput coli that lies to the right side of the

anterior band grows out of proportion to that part to the left of the band. The anterior wall becomes more developed than the posterior, so that the apex is turned so much to the left and posteriorly that it nearly meets the ileo-cæcal junction. A false apex is formed by the highly developed part to the right of the anterior band. This is the usual cæcum found (fig. 575, C.).

4. In the fourth type, the development of the part to the right of the anterior band is excessive, while the segment to the left of the band has atrophied. In this form the anterior band runs to the inferior angle of junction of the ileum with the cæcum. The root of the appendix is posterior to that angle. There is no trace of the original apex, and the appendix appears to spring almost from the ileo-cæcal junction (fig. 575, D.).

Other variations.—The cæcum may vary in its general development. It is sometimes small and insignificant, in other cases it reaches a large size. It may be so rotated that the ileum passes behind the colon and opens on the right side. The posterior part has been seen much more developed than the anterior, so that the ileum has entered from the front, and the appendix has come off from the anterior wall. The cæcum may remain undescended, and be found just under the liver or in the vicinity of the umbilicus. The cæcum and colon may be suspended by a mesentery common to the whole intestinal canal. In such cases the primitive condition of the peritoneal fold which supports the small and large intestine is permanently retained (page 997).

The vermiform appendix.—Attached to what is really the original apex of the cæcum is a narrow, blind tube: this is the vermiform appendix. It usually comes off close to the ileo-cæcal valve on the inner and posterior side of the bowel, though occasionally it forms the true apex of the cæcum. In the adult the average length is four inches, the extremes being one inch and six inches. In the majority of instances the appendix is much twisted upon itself. Its usual position is behind the end of the ileum and its mesentery, and pointing in the direction of the spleen. It may occasionally ascend vertically behind the cæcum.

It has a definite mesentery, which comes off from the left layer of the mesentery of the ileum. Its origin from this layer is along a straight line which is situated at a short distance from the intestine, and which is not quite parallel with the margin of the bowel. In general outline the mesentery is triangular. In the adult it does not extend along the whole length of the tube. It is, in fact, too short for the appendix, and it is this that accounts for the twisted condition of the little process. Along the free margin of the mesentery runs a branch of the ileo-colic artery.

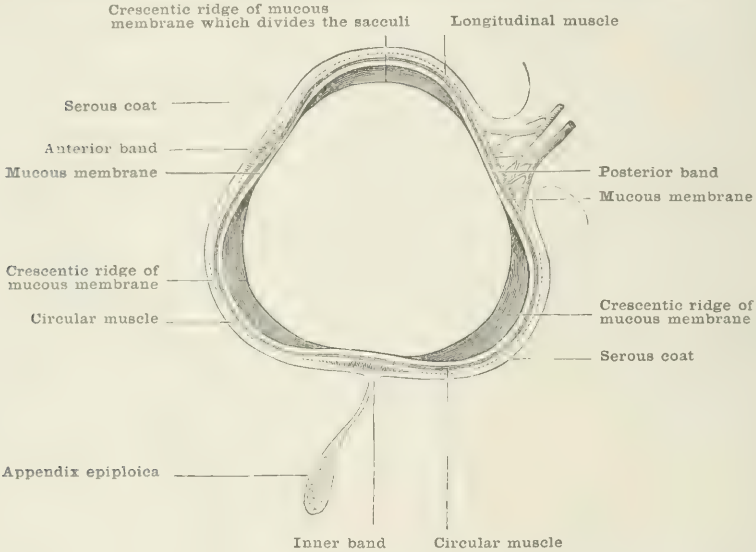
Ileo-cæcal fossa.—About the cæcum, and especially in the vicinity of the ileo-cæcal junction, are certain fossæ collectively known as the ileo-cæcal. Two only appear to be fairly constant. The first, the *superior ileo-cæcal*, is formed by the passage across the junction of the cæcum and ileum of a branch of the ileo-colic artery, which produces a fold of peritoneum limiting a pouch. It is on the anterior aspect of the bowel, and the pouch opens downwards.

The second fossa is not quite so simple. If the cæcum be turned upwards so as to expose its posterior surface as it lies *in situ*, and if the appendix be drawn down so as to put its mesentery on the stretch, a peculiar fold will be found to join that mesentery. This fold arises from that border of the ileum which is most remote from the insertion of its mesentery. It then passes over the ileo-cæcal junction on its inferior aspect, is adherent to the cæcum, and finally joins the surface of the mesentery of the appendix. This fold is peculiar in the absence of any visible vessels. Between it and the appendix there is an almost constant fossa, the *inferior ileo-cæcal*. It is large, admitting two fingers. It opens outwards, and is bounded on one side by the small intestine, and on the other by the cæcum.

The ileo-cæcal valve.—The ileo-cæcal valve, which is situated at the entrance of the ileum into the large intestine at the upper border of the cæcum, is found on the inner side and towards the posterior aspect of the intestine. The ileum passes from below upwards and towards the right, and terminates with a considerable degree of obliquity. The valve is formed by two semilunar folds projecting into the large intestine, the upper being nearly transverse, the lower being a little oblique. The opening between them takes the form of a narrow slit about half an inch in length, rounded in front but narrow behind. At the ends of the slit the valves unite and are prolonged at either end as a ridge partially surrounding the intestine (frænæ). Villi cover that surface of the folds looking towards the ileum. The surface towards the large intestine is free from villi. In the formation of this valve the longitudinal muscular fibres pass across from the ileum to the large intestine without dipping down between the two layers of each fold. The circular muscular fibres, on the other hand, are contained between the layer of the mucous membrane and submucous tissue which form them.

The colon.—In the adult the ascending and the descending parts of the colon are placed vertically, while the direction of the transverse colon is practically horizontal. The average length in the adult of the ascending colon (as measured from the tip of the cæcum to the hepatic flexure) is eight inches, and of the descending colon (as measured from the splenic bend to the commencement of the sigmoid loop) is eight and a half inches. The descending colon is the part of the large bowel that is least liable to variation. It is the only part of the gut except the duodenum that retains its original position as a portion of the great primary vertical loop. The transverse colon, on the other hand, is liable to considerable variation in length, position, and arrangement. Its average length is twenty inches in the adult. It has been found to vary in adults from twelve to thirty-three inches.

Fig. 576. Section of the Ascending Colon. (Allen Thomson.)


Crescentic ridge of mucous membrane which divides the sacculi
Longitudinal muscle
Serous coat
Anterior band
Mucous membrane
Posterior band
Mucous membrane
Crescentic ridge of mucous membrane
Circular muscle
Crescentic ridge of mucous membrane
Serous coat
Appendix epiploica
Inner band
Circular muscle

The ascending colon.—The ascending colon extends from the cæcum to the inferior surface of the liver external to the gall bladder, forming there the hepatic flexure. It is covered by peritoneum in front and at the side, but in a certain proportion of cases (twenty-six per cent. in one hundred dissections) this part of the large intestine is connected with the posterior wall of the abdomen by a mesocolon, that is to say, it is quite surrounded by peritoneum. Connected with the ascending colon is sometimes found a fold of peritoneum, extending from the right side of the gut to the parietes at a little above the level of the highest part of the iliac crest. It forms a shelf upon which rests the extreme right margin of the liver. It might be called the *sustentaculum hepatis*.

The ascending colon is in relation behind with the right kidney, second portion of the duodenum, and quadratus lumborum. In front are some of the coils of the ileum (fig. 577).

The transverse colon:—The transverse colon, smaller in diameter than the ascending, extends from the under surface of the liver to the spleen. Being longer than a straight line between these two points, it has to describe an arch with its convexity forwards; it also bends a little downwards. It crosses through the umbilical region from the right hypochondrium to the left hypochondrium (fig. 565).

In the majority of cases the superficial part of the colic arch—as seen before the viscera are disturbed—is either in whole or in greater part above a straight line drawn transversely across the body between the highest points of the iliac crest. In the proportion of one to four it lies, in whole or in greater part, below this line (fig. 582).

Certain remarkable bends are sometimes formed by this part of the bowel. The bending is always in the same direction, namely, downwards, and is usually abrupt and angular. The apex of the V or U-shaped bend thus formed may reach the pubes. This bend appears to be due to two distinct causes: namely, long-continued distension on the one hand, and to congenital malformation on the other.

The transverse colon is in relation above with the liver and gall bladder, the stomach, and at its left extremity with the spleen. The third portion of the duodenum passes behind it. Below are the coils of the small intestine. It is surrounded with peritoneum, being connected with the posterior abdominal wall by a meso-colon.

The **descending colon** extends from the spleen to the sigmoid flexure. It is more movable than the ascending colon. It is also narrower. At its beginning it is connected with the diaphragm, on a level with the tenth and eleventh ribs, by a fold of peritoneum, the *costo-colic ligament* (or sustentaculum lienis, from the fact that it supports the spleen). The bend between the transverse colon and descending colon is called the splenic flexure. The descending colon is situated in the left hypochondriac and lumbar regions (fig. 591). Its relations to the peritoneum are the same as obtain with the ascending colon, that is, it is covered in front and on the sides. A meso-colon is met with oftener on this side than on the right. In one hundred dissections it was found thirty-six times. The descending colon is covered in front by the small intestine; behind, are part of the diaphragm, the left kidney, and the quadratus lumborum muscle (fig. 577).

The sigmoid flexure and rectum.—The segment of gut termed the sigmoid flexure, and the so-called first part of the rectum, form together a single simple loop that cannot be divided into parts. This loop begins where the descending colon ends, viz., in the left iliac fossa, and ends at the commencement of the so-called second piece of the rectum—at the spot where the meso-rectum ceases, opposite about the third piece of the sacrum in the median line. The loop when unfolded describes a figure that may be compared to the capital omega. The average length of this sigmoid or omega loop is seventeen inches and a half. The normal position of the loop is not in the left iliac fossa, but wholly in the pelvis. The most common disposition of it may now be described.

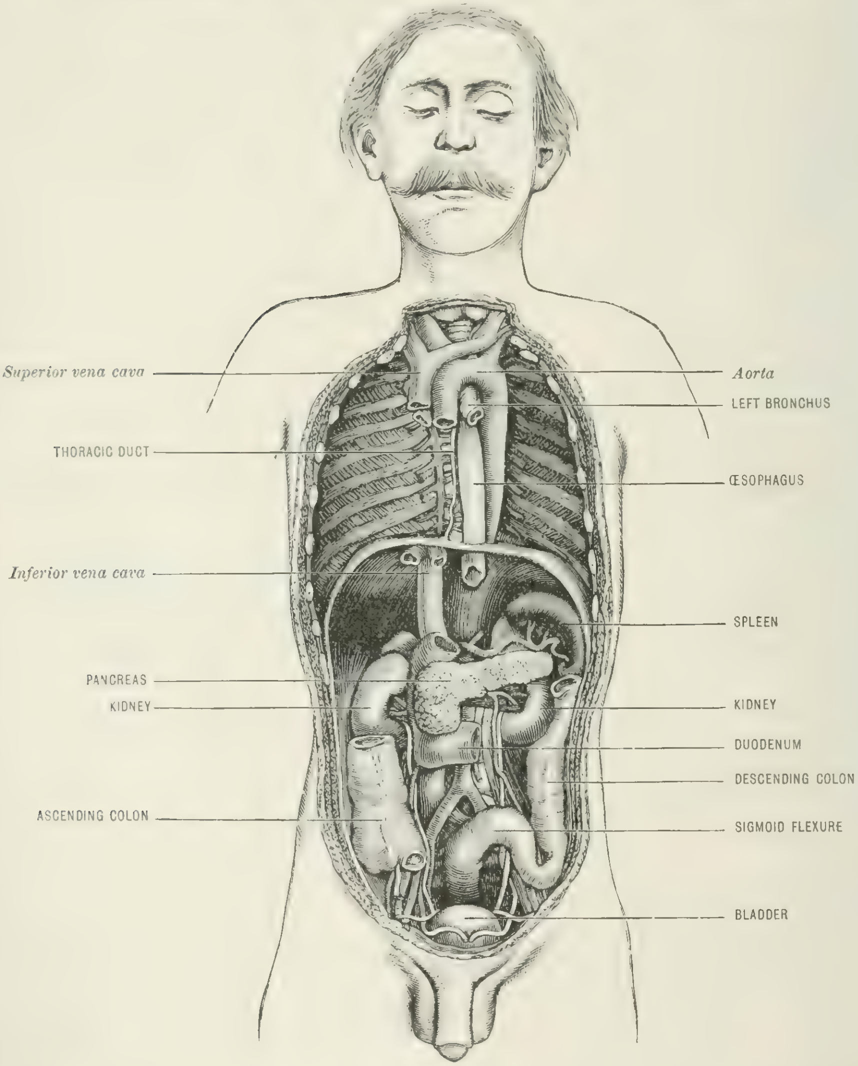
The descending colon ends just at the outer border of the psoas. The gut here suddenly changes its direction, and the sigmoid or omega loop begins (figs. 565, 577). The bowel crosses the muscle at right angles and about midway between the lumbo-sacral eminence and Poupart's ligament. It now descends vertically along the left pelvic wall, and may at once reach the pelvic floor. It then passes more or less horizontally and transversely across the pelvis from left to right, and commonly comes into contact with the right pelvic wall. At this point it is bent upon itself, and, passing once more towards the left, reaches the middle line and descends to the anus. It will lie therefore in more or less direct contact with the bladder and uterus, and may possibly touch the cæcum. It is very closely related with the coils of small gut that occupy the pelvis, and by these coils the loop is usually hidden.

The sigmoid or omega loop is attached to the abdominal and pelvic wall by a meso-colon, so that it is quite surrounded by peritoneum. The line of attachment of this meso-colon is as follows: It crosses the psoas at a right angle, and then takes a slight curve upwards so as to pass over the iliac vessels at or about their bifurcation. The curve ends at a point either just to the inner side of the psoas muscle, or between the psoas and the middle line, or, as is most frequently the case, just over the bifurcation of the vessels. From this point the line of attachment proceeds vertically down, taking at first a slight curve to the right. Its course is to the left of the middle line, while its ending will be upon that line, about the third piece of the sacrum. The sigmoid meso-colon measures from one and a quarter to three and a half inches in width—*i. e.*, from the parietes to the bowel.

When a descending meso-colon exists it joins that of the loop, and the line of attachment is then, as a rule, directed obliquely across the psoas and the lower end of the kidney, while beyond the pelvic brim the attachment is as above described.

There is often no meso-colon over the psoas, the gut being adherent to that muscle.

FIG. 577.—VIEW OF THE DEEPER ABDOMINAL VISCERA. (Rüdinger.)


Superior vena cava
Aorta
LEFT BRONCHUS
THORACIC DUCT
ŒSOPHAGUS
Inferior vena cava
SPLEEN
PANCREAS
KIDNEY
KIDNEY
DUODENUM
DESCENDING COLON
ASCENDING COLON
SIGMOID FLEXURE
BLADDER

In connection with the sigmoid meso-colon is often found a fossa or pouch of peritoneum, known as the *intersigmoid fossa*. The pouch is formed by the layers of the meso-colon, and is produced by the sigmoid artery. It is generally found over the bifurcation of the iliac vessels. The pouch is funnel-shaped, and the opening looks downwards and to the left. The fossa varies in depth from one to one and a half inches, and is the seat of the sigmoid hernia.

The rectum.—The rectum has been described as divided into three portions. Such division is quite arbitrary, and is inconvenient. What is usually described as the first portion has, in the account just given, been included with the sigmoid flexure.

The two remaining portions of the intestine extend from the middle of the third piece of the sacrum to the anus.

It would be well if the term 'rectum' were to be limited to that part of the bowel which is below the level of the third segment of the sacrum, and which is free of any meso-colon. This portion of bowel—the rectum proper—may be divided into two portions. The first portion extends from the third piece of the sacrum to the tip of the coccyx.

This portion, about three and a half inches long, is only covered by peritoneum above, and then only over the anterior surface. Behind, it is in relation with the sacrum and coccyx. In front it is in relation with the trigone of the bladder, the vesiculæ seminales, and under surface of the prostate. In the female the anterior surface is in relation with the vagina and the cervix uteri.

The peritoneum is reflected from the rectum to the bladder in the male, and the vagina in the female (recto-vesical or recto-vaginal pouch). This pouch extends in the male to within about three inches of the anus. On the posterior surface of the gut there is no peritoneum below a point five inches from the anus.

The second portion (or what used to be called the third portion) extends from the tip of the coccyx to the anus; it is about an inch and a half long. It differs from the first portion in the direction of its curve: while that follows the curve of the sacrum and coccyx, this portion turns backwards and downwards. It is not connected with the peritoneum. It is surrounded, after leaving the prostate, by the internal sphincter, while the levator ani is attached to its side. At its end the external sphincter is situated; in front is the triangular ligament of the perineum. Just above the anus the rectum is much dilated.

The anus.—The anus is the aperture by which the intestine opens externally. During life it is contracted by the sphincters, so as to give the skin around a wrinkled appearance. Round the lower part of the rectum and anus certain muscles that are connected with its proper function are situated. They are the internal sphincter, the levator ani, and the external sphincter. The levator ani and external sphincter will be found described in another part.

The *internal sphincter* is a thickening of the circular fibres of the intestine, situated round the rectum about an inch above the anus, and extending over half an inch of the intestine. It forms a complete muscular ring. It is two lines thick, and is paler than the external sphincter.

The rectum differs from the rest of the colon in presenting perfectly smooth walls marked by no sacculi, by no longitudinal muscular bands, and by no appendices. The mucous membrane of the rectum is thicker than that of the rest of the large intestine. Certain folds, chiefly longitudinal in direction, are seen in the lax state of the tube, which disappear when distended. Houston has described three oblique semilunar folds, which project into the lumen of the tube: one in front by the prostate, and two others higher up; one from the left side, and one on the right, the highest.

Structure of the large intestine.—There are four coats: a serous, muscular, mucous, and submucous.

The *serous* is derived from the peritoneum, and is more or less complete.

The appendices epiploicæ in connection with this layer have been mentioned (fig. 576).

The *muscular coat* is divided into circular and longitudinal layers, the longitudinal being external. The arrangement of the longitudinal fibres has been described in as far as they make up the three longitudinal bands (fig. 576). Only a small amount of longitudinal fibres are found between the bands, except on the vermiform appendix and lower part of the sigmoid flexure, where they are arranged all round.

The circular fibres form a thin layer, and are mostly collected in the interval between the sacculi.

The *mucous membrane*, separated from the muscular layer by the *submucous layer*, has no villi, and no valvulæ conniventes.

Blood-vessels.—The large intestine is supplied with blood by the branches of the superior mesenteric and inferior mesenteric arteries, while it also receives a blood-supply from the internal iliac at the rectum. The vessels form a continuous series of arches from the cæcum, where the vasa intestini tenuis anastomose with the ileo-colica, the first branch of the superior mesenteric given to the large intestine.

The blood-supply of the rectum is from the inferior mesenteric by the superior hæmorrhoidal, from the internal iliac by the middle hæmorrhoidal, and from the internal pudic by the inferior hæmorrhoidal. The vessels at the lower end of the rectum assume a longitudinal direction, communicating freely near the anus, and less freely above.

The blood of the large intestine is turned into the portal vein by means of the superior mesenteric and inferior mesenteric veins. At the rectum a communication is set up between the systemic and portal system of veins, since some of the blood of that part of the intestine is returned into the internal iliac veins. In the lower end of the rectum the veins, like the arteries, are arranged longitudinally. This arrangement is called the hæmorrhoidal plexus.

The **nerves** and **lymphatics** of the large intestine differ in no important particular from those of the small intestine.

THE LIVER

The **liver**—the largest gland in the body—is situated in the upper and right part of the abdominal cavity (figs. 565, 578). It is of most irregular shape. It **weighs** between forty-five and sixty ounces. In females the liver is smaller than in males. It bears a different relation to the body weight at different ages. It forms one-fortieth part of the weight of the body in the adult male, and one-thirty-sixth in the adult female. In the fœtus, at the fourth month, it is one-tenth the weight of the body, and in the infant at birth one-twentieth (fig. 578). It measures from right to left seven to ten inches, from before backwards three to six inches, and six to seven inches from above downwards in the thickest part of the right lobe. It is of a chocolate or reddish-brown color, is solid and firm to the touch, but friable. Its bulk is equal to ninety-five cubic inches.

In the description which follows it will be noted that there are two **borders**—anterior and posterior; two **extremities**—right and left; three **surfaces**—superior, inferior, and posterior; five **lobes**—right, left, quadrate, caudate, and Spigelian; five **fissures**—umbilical, fissure for the ductus venosus, transverse, fissure of the vena cava, fissure for the gall bladder; five **ligaments**—coronary, suspensory or falciform, round, right and left lateral.

The liver is seen to be divided by means of a fold of peritoneum—the suspensory ligament—into two very distinct parts, the right and left lobes (figs. 578, 579).

The **anterior border** of the liver is well defined, appearing as a sharp thin edge. To the left of the middle point at the beginning of the longitudinal fissure is the interlobar notch, marking the division between the right and left lobes. Further to the right is a notch for the gall bladder.

The **posterior border** is thick, rounded, and fixed, is slightly marked by the spinal column, and notched for the vena cava.

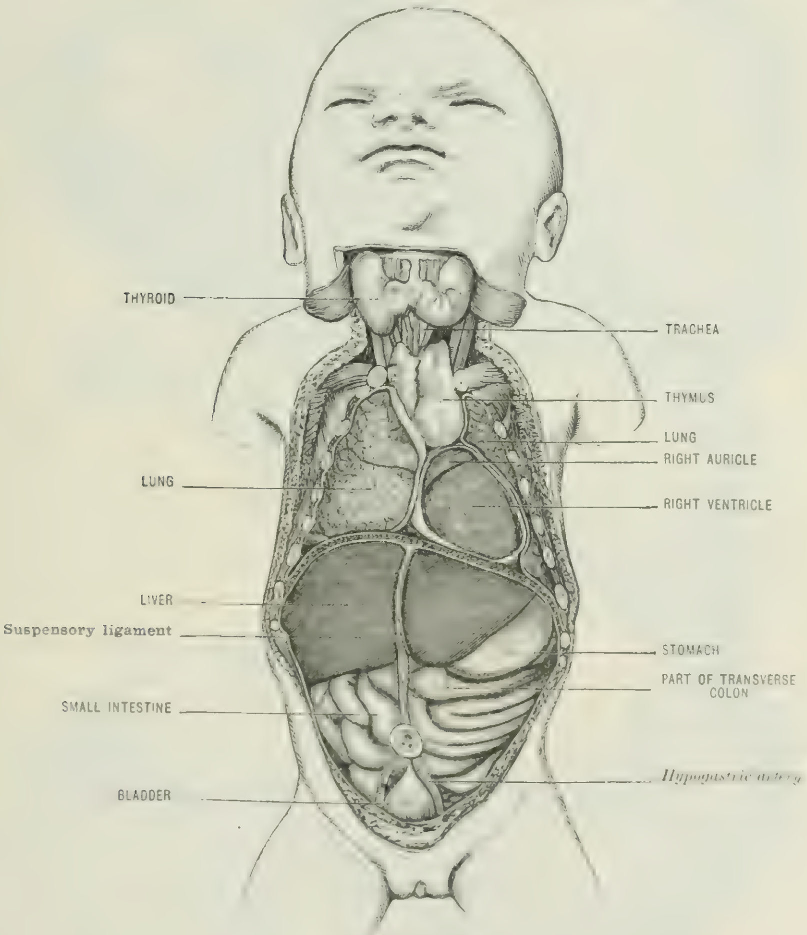
The **right extremity** is thick, and rounded like the posterior border. The **left extremity** is thin and flat like the anterior border.

The **surfaces** are described as they are seen in a liver which has been hardened *in situ*.

The **superior surface** of the liver is convex, and moulded to the surface of the diaphragm. It is smooth, and covered by peritoneum. It is divided by the suspensory ligament, which runs from before backwards, into two parts: the right and left lobes, the right division being much the larger (fig. 579). Upon this surface of the left lobe is a shallow depression for the heart. The surface of the left lobe is much less convex than that of the right. A considerable portion of this surface faces anteriorly, and some writers divide it into anterior and upper surfaces.

The **inferior surface** consists of that part of the liver in front of and including the transverse fissure. It is irregularly concave. It is covered by peritoneum, except where the gall bladder comes in contact with its surface, and at the transverse fissure where the lesser omentum leaves the liver. It consists of three parts —viz., the quadrate lobe, nearly all the left lobe, and the under surface of the right lobe (fig. 580). This inferior surface is divided into right and left sections by the longitudinal fissure which forms the inferior separation between the right and left lobes. The part of the **longitudinal fissure** seen on this surface is known as the **umbilical fissure** from its containing during fœtal life the umbilical vein, the remains of which are now to be seen as the round ligament. It runs from before backwards, meeting the transverse fissure behind. The portion of the left lobe included on this surface is much smaller than the similar surface of the right lobe. It lies over the cardiac part of the stomach and the anterior surface adjoining the lesser curvature, and shows an impression (*impressio gastrica*) made by that organ. Its anterior border is sharp and free; but behind, the separation from the posterior surface is very ill defined.

FIG. 578.—THE VISCERA OF THE FŒTUS. (Rüdinger.)



The under surface of the right lobe is divided into two by the gall bladder, which is contained in a fossa (the *fossa of the gall bladder*). The inner of these two portions, which is bounded by the umbilical fissure to the left, the fossa of the gall bladder to the right, and the transverse fissure behind, is called the **quadrate lobe,** and is connected with the left lobe very often by a bridge of liver substance (pons hepatis) across the umbilical fissure. The outer of the two portions is much the larger, and presents three depressions upon its surface: an anterior one for the hepatic flexure of the colon (*impressio colica*), a posterior one for the right kidney (*impressio renalis*), and one situated on the inner side of the impressio renalis for the descending part of the duodenum (*impressio duodenalis*). In a hardened liver these impressions are well marked, and are separated by well-defined ridges.

FIG. 579.—SUPERIOR SURFACE OF THE LIVER.

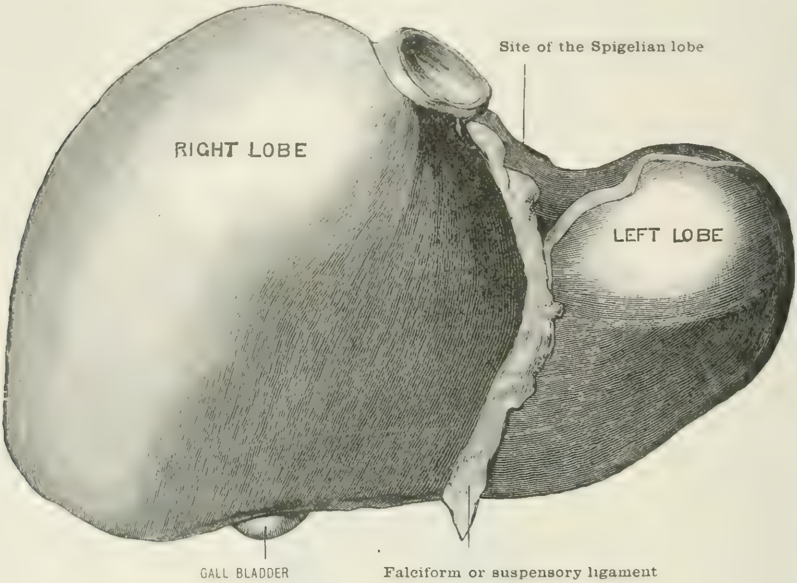
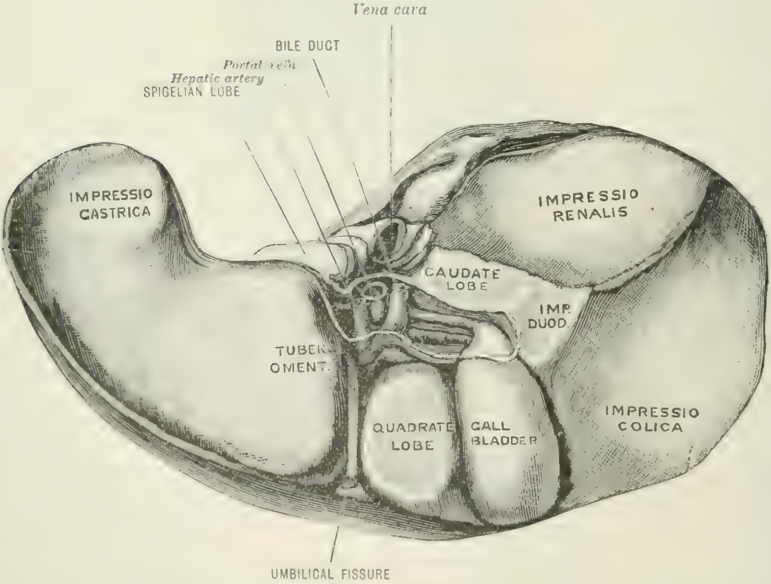

Site of the Spigelian lobe
RIGHT LOBE
LEFT LOBE
GALL BLADDER
Falciform or suspensory ligament

FIG. 580.—THE INFERIOR SURFACE OF THE LIVER.

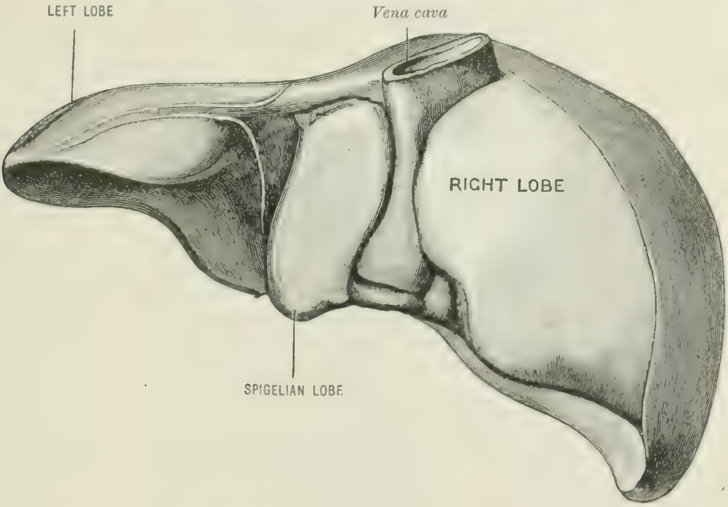

Vena cava
BILE DUCT
Portal vein
Hepatic artery
SPIGELIAN LOBE
IMPRESSIO GASTRICA
IMPRESSIO RENALIS
CAUDATE LOBE
IMP. DUOD.
TUBER OMENT.
QUADRATE LOBE
GALL BLADDER
IMPRESSIO COLICA
UMBILICAL FISSURE

The **posterior surface** is directed backwards towards the vertebral column, at which part it is concave. It includes that part of the liver behind the transverse fissure, and consists of the following parts (fig. 581):—

(1) The posterior portion of the left lobe, not very well defined; it presents a protuberance (the *tuber omentale*) in front, which projects against the lesser omentum; behind, a concavity coming in contact with the cardia.

This portion is separated by means of the **fissure of the ductus venosus** from (2) the **Spigelian lobe,** which lies between this fissure and that of the vena cava. This lobe is directed backwards, is longer from above downwards than from side to side, and is somewhat concave from side to side. It is opposite to the tenth and eleventh thoracic vertebrae, and rests on the crura of the diaphragm. Behind its upper left-hand corner the oesophagus passes to enter the stomach. Below, it projects and forms part of the posterior boundary of the transverse fissure. It is connected with that part of the right lobe which enters into the posterior surface by means of (3) the **caudate lobe,** which is a small mass of liver substance running from left to right behind the transverse fissure. It lies directly over the foramen of Winslow. It varies a good deal in form; is sometimes well defined, at other times hardly to be seen. When well defined, it is about two to three inches long; behind is the termination of the fissure of the vena cava.

Fig. 581.—Posterior Surface of the Liver.



(4) The portion of the right lobe taking part in the posterior surface consists of a strip two and a half to three inches broad (Quain). This is uncovered by peritoneum, except at the extreme right. Lying between the two layers of the coronary ligament close to the vena cava and near the caudate lobe is an impression for the right suprarenal capsule (*impressio suprarenalis*).

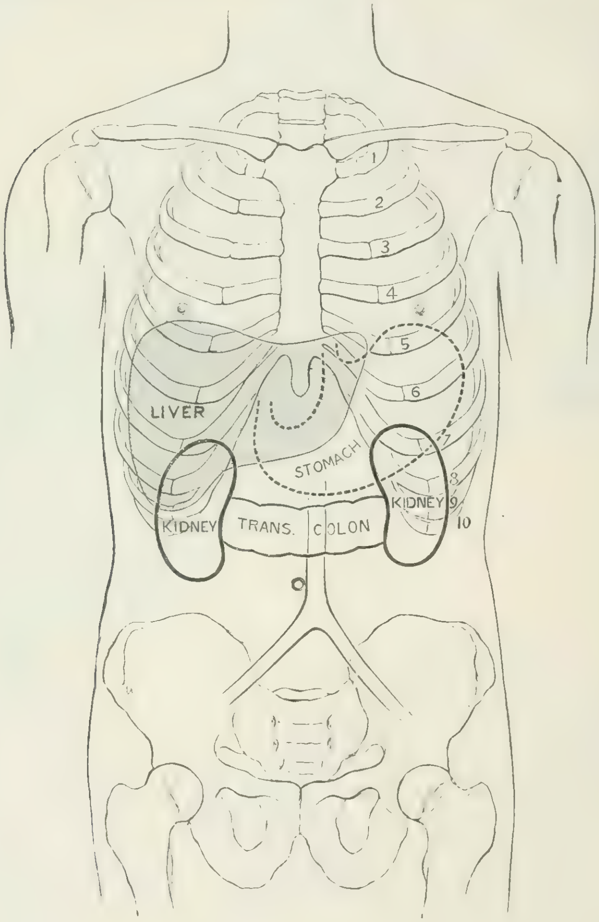
Fissures.—The fissures on the inferior and posterior surfaces of the liver are arranged very like a capital letter **H**. The left upright of the **H** is formed by the **longitudinal fissure**; the anterior portion containing the umbilical vein is seen on the inferior surface, and is known as the **umbilical fissure**; the posterior portion, seen on the posterior surface, contains the ductus venosus, and is therefore called the **fissure of the ductus venosus.** The transverse bar of the **H** is formed by the **transverse** or **portal fissure,** which runs across at right angles to the longitudinal fissure, and contains the vessels entering the liver, viz., the portal vein, hepatic artery, and hepatic duct (fig. 580).

The right upright of the **H** is formed by the **fossa of the gall bladder** in front: it is interrupted by the caudate lobe; and is continued behind as the **fissure of the vena cava,** containing, as its name implies, the inferior vena cava.

General position.—The liver is situated in the right hypochondriac and epigastric regions, and usually extends into the left hypochondrium (fig. 582). It is opposite the ninth, tenth, and eleventh dorsal vertebræ behind (fig. 583), and on the right side extends between the seventh and eleventh ribs; in front, it lies behind the fifth, sixth, seventh, eighth, and ninth costal cartilages; and its anterior border corresponds on the right to the line of the margin of the costal cartilages, and to the left it is in contact with the anterior abdominal wall below the sternal notch (fig. 582).

The liver is very movable, and alters its position under various circumstances. It is depressed at each inspiration, the anterior border being pushed below the ribs by a deep breath. When lying down, the liver edge is half an inch above the margin of the ribs. In children, the gland being larger in proportion to the body than in the adult state, it extends below the ribs and reaches the left hypochondrium.

FIG. 582.—RELATION OF THE ABDOMINAL VISCERA TO THE PARIETES. (Treves.)



The liver's extreme left point is about an inch and a half beyond the left margin of the sternum; in front, in the middle line, it reaches to about half way between the xiphoid cartilage and the navel. The lower edge as it crosses the subcostal angle is represented by a line drawn from the ninth right to the eighth left costal cartilage. (Quain.)

Its upper limit is indicated by a line crossing the mesosternum close to its lower end, and rising on the right side in the mammary line to the level of the fifth rib. On the left the line is practically horizontal. Behind, the liver is nearest the surface at the tenth and eleventh thoracic vertebræ.

Its upper convex surface is in contact with the whole of the right arch of the diaphragm and a part of the left, as well as with the ribs and the anterior wall of the abdomen.

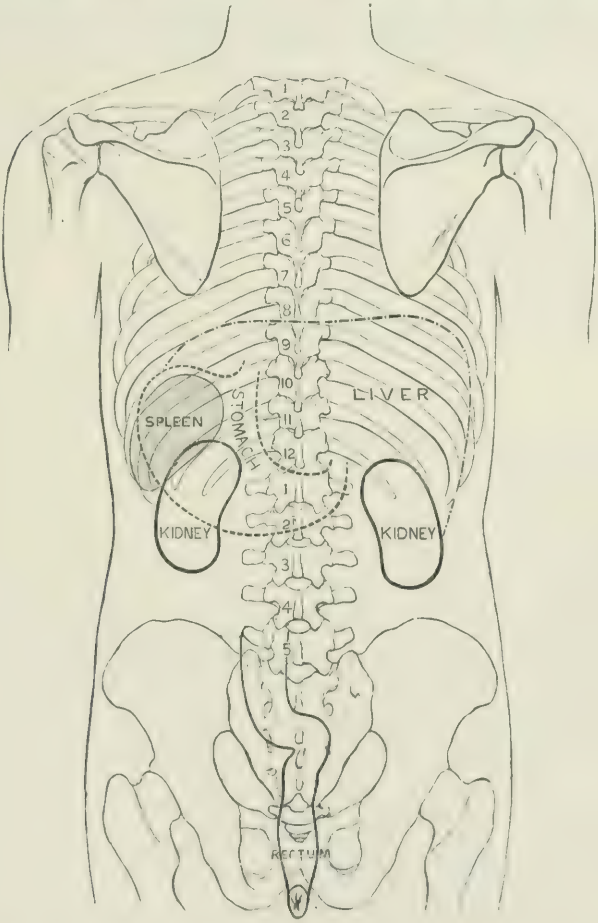
The under surface.—The left lobe lies over the cardiac end and a portion of the anterior wall of the stomach.

The right lobe lies over the hepatic flexure of the colon and right kidney, and descending portion of the duodenum.

The quadrate lobe lies over the pyloric end of the stomach and first part of the duodenum.

The posterior surface.—The Spigelian lobe lies against the tenth and eleventh thoracic vertebræ, the right crus of the diaphragm, and the lower end of the œsophagus. That portion of the right lobe which takes part in this surface lies against the right suprarenal capsule and diaphragm.

FIG. 583.—RELATIONS OF THE ABDOMINAL VISCERA TO THE PARIETES. (Treves.)



The inferior vena cava lies in a groove in this lobe. The small portion of the left lobe taking part in the posterior surface lies against the œsophagus.

The fundus of the gall bladder is opposite the ninth costal cartilage, close to the outer margin of the right rectus muscle.

Relation to the peritoneum.—The liver is received between the layers of the gastro-hepatic omentum. The *anterior layer* on leaving the transverse fissure passes along to the anterior border of the liver, where it meets the round ligament, encloses it, and is then continued on to the superior surface in two portions, owing to the intervention of the round ligament, the two layers reflected on to this structure being known as the suspensory ligament. At the posterior border of the superior surface it leaves the liver and forms the upper layer of the coronary ligament.

The *posterior layer* of the gastro-hepatic omentum passes backwards, covers a portion of the posterior surface of the liver, and leaves uncovered that part of the right lobe (except the extreme right) which takes part in this surface. It is finally reflected to form the inferior layer of the coronary ligament.

The parts of the liver uncovered by peritoneum are: the transverse fissure, the fossa of the gall bladder, and that portion of the posterior surface made up by the right lobe, and to which allusion has already been made.

Underneath the peritoneal investment of the liver is a thin fibro-elastic membrane which is intimately adherent to the peritoneum, and is continuous over the liver where the peritoneum is deficient. At the transverse fissure this fibrous layer invests the hepatic vessels, forming a special sheath which follows the vessels as they enter the liver: this structure receives the name of Glisson's capsule.

ABOVE.

Diaphragm and anterior wall of abdomen.

BEHIND.

Tenth and eleventh thoracic vertebræ; crura of diaphragm; lower end of œsophagus; right suprarenal capsule; great vessels.

GENERAL
RELATIONS
OF THE LIVER

BELOW

Cardiac end of stomach; hepatic flexure of colon; right kidney; first and second portions of duodenum.

Ligaments of the liver.—With the exception of the round ligament, the ligaments are formed by the peritoneum, and (with the same exception) are all attached to the diaphragm. The reflexion of the two layers of peritoneum from the posterior surface of the liver to the diaphragm, as just described, forms the **coronary ligaments**, the extremities, or lateral continuations, being called the **right** and **left lateral ligaments.** The left lateral ligament is the longer, and is attached to the diaphragm in front of the œsophagus. The right is attached to the back part of the diaphragm.

The **broad ligament** (falciform or suspensory ligament) is also continuous behind with the coronary ligament; it is formed by the adjacent surfaces of the two portions of peritoneum covering the superior surface; it extends from the umbilicus where is the apex of the falx. The upper rounded border is connected with the anterior abdominal wall and diaphragm. The free or anterior border contains the round ligament; the lower or attached border extends from before backwards on the upper surface of the liver.

The **round ligament** is a fibrous cord (the remains of the umbilical vein), extending on the free border of the broad ligament from the longitudinal fissure to the umbilicus.

Blood-vessels.—The liver receives its *arterial* supply of blood from the hepatic artery, a branch of the cœliac axis, which passes up between the two layers of the lesser omentum, and, dividing into two branches, one for each lobe, enters the liver at the transverse fissure. The right branch gives off a branch to the gall bladder. The liver receives a much larger supply of blood from the *portal vein,* which conveys to the liver blood from the stomach, intestines, pancreas, and spleen. It enters the transverse fissure, and there divides into two branches. Below this fissure the hepatic artery lies to the left, the bile duct to the right, and the portal vein behind and between the two (fig. 584). These three structures ascend to the liver between the layers of the gastro-hepatic omentum in front of the foramen of

Winslow. At the actual fissure the order of the three structures from before backwards is—duct, artery, vein.

The *hepatic veins*, by which the blood of the liver passes into the inferior vena cava, open by several large and small openings into that vessel at the posterior surface of the gland at the bottom of the fossa of the vena cava.

Lymphatics.—The lymphatics are divided into a deep and a superficial set. The *deep set* run with the branches of the portal vein, artery, and duct through the liver, leaving at the transverse fissure, where they join the vessels of the superficial set.

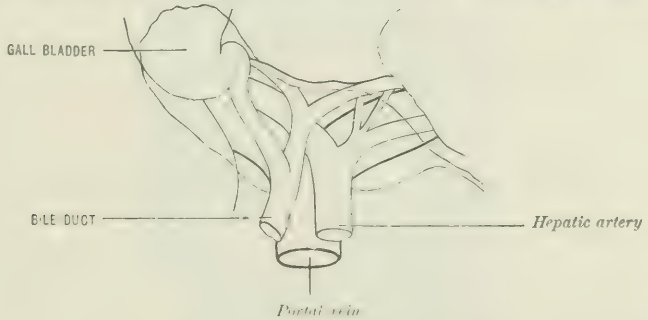
The *superficial set* begin in the subperitoneal tissue. Those of the upper surface consist:—(1) Of vessels which pass up, principally, in the broad ligament and right and left lateral ligaments, through the diaphragm, and so into the anterior mediastinal glands; occasionally lymphatics of the right ligament pass straight into the thoracic duct. (2) Of a set passing over the anterior border of the liver to the glands in the small omentum about the transverse fissure.

On the under surface, the lymphatics to the right of the gall bladder enter the lumbar glands.

Those round the gall bladder enter the glands of the lesser omentum.

Those to the left of the gall bladder enter the glands of the œsophagus and lesser curvature of the stomach.

FIG. 584.—RELATION OF STRUCTURES AT AND BELOW THE TRANSVERSE FISSURE. (Thane.



Structure of the liver.—If a section be made of the liver, the following features in its general structure may be noted:—

Outside of all will be seen the investment of *peritoneum*, which is incomplete in parts, and which has been already described.

Within this a thin *fibrous coat* will be observed to invest the entire gland. At the transverse fissure this coat turns into the substance of the liver with the branches of the portal vein.

Glisson's capsule.—The capsule is in all parts closely adherent to the gland-substance, and is thickest where the peritoneum is absent.

The liver on section is seen to be mottled, and when a portion is torn the surface presents a granular appearance. This is produced by the minute **lobules** (one twenty-fourth to one-twelfth of an inch in diameter) of which the liver tissue is composed.

The cut surface will also exhibit the openings of a number of canals. A slight examination will show that these are of two kinds—viz. the canals for the branches of the portal vein and the canals for the hepatic veins.

In the *portal canals* the vein is accompanied by a branch of the duct and a branch of the hepatic artery. The vein has thick walls which will be seen to be more or less collapsed on section. The vessels in the canal are separated from the liver substance by much connective tissue (Glisson's capsule, fig. 585).

In the *hepatic canals* the veins are solitary, their walls are exceedingly thin, and their mouths open and gaping. The wall of the vein is directly adherent to the liver substance, no connective tissue capsule intervening.

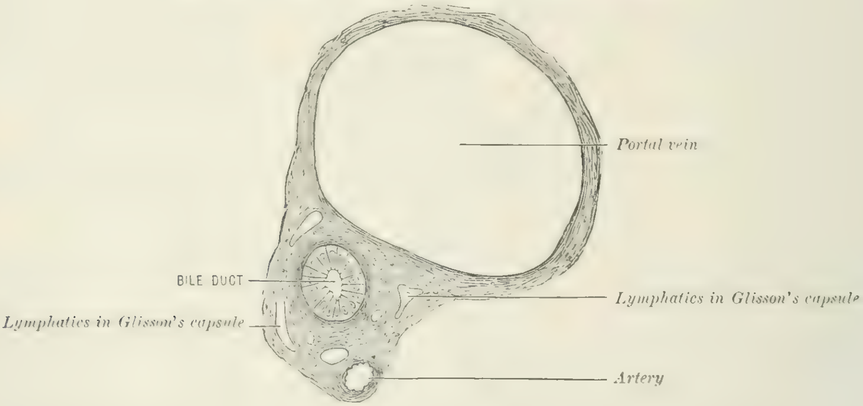
The **gall bladder**, which retains the bile, is situated between the right and quadrate lobes on the under surface of the liver. It is of pyriform outline, and when full is seen projecting beyond the anterior border of the liver, coming in contact with the abdominal wall opposite the ninth costal cartilage. It extends back as far as the transverse fissure.

It measures in length, from before backwards, from two and a half to four inches (75 to 100 mm.), and an inch and a half (35 mm.) across at the widest part, and will hold about one ounce. The broad end of the sac is directed forwards, downwards, and to the right, and is called the *fundus*. The narrow end, or *neck*, which is curved first to the right, then to the left, is at the transverse fissure. The intervening part is called the *body*.

Its *upper surface* is in contact with the liver, lying in the fossa of the gall bladder. It is attached to the liver by connective tissue. The lower surface is covered by peritoneum, which passes over its sides and inferior surface, though occasionally it entirely surrounds the gall bladder, forming a sort of mesentery to attach it to the liver. The lower surface comes into contact with the first part of the duodenum and hepatic flexure of the colon, and occasionally with the pyloric ends of the stomach or small intestine, which are often *post mortem* found stained with bile.

The neck of the gall bladder opens into the *cystic duct*. This is a tube an inch and a half long (35 mm.) and one-twelfth of an inch wide (2.3 mm.), which unites with the hepatic duct to form the common duct; it is directed backwards and to the left as it runs in the lesser omentum, the hepatic artery being to the left and the portal vein behind. It joins the hepatic duct at an acute angle.

FIG. 585.—SECTION OF A PORTAL CANAL. (Quain.)


Portal vein
BILE DUCT
Lymphatics in Glisson's capsule
Lymphatics in Glisson's capsule
Artery

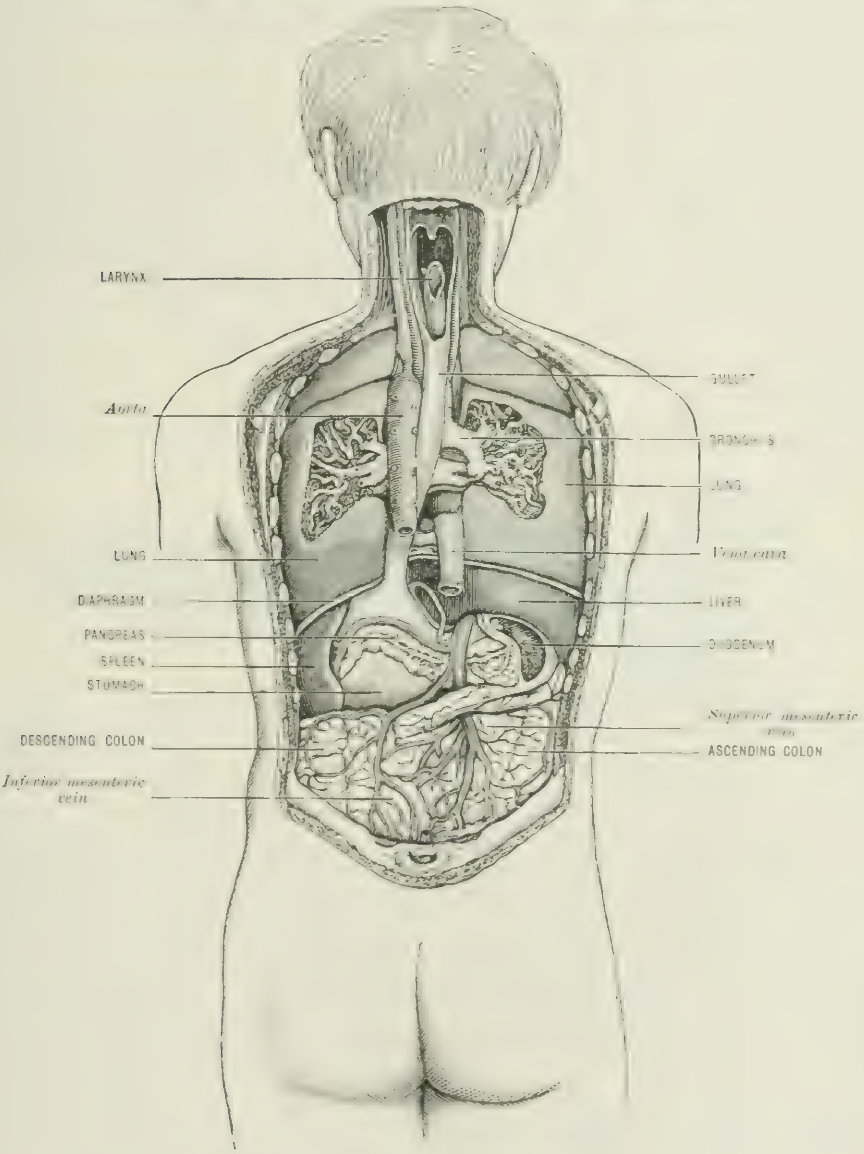
The *hepatic duct* begins with a branch from each lobe right and left in the transverse fissure, and is directed downwards and to the right in the folds of the lesser omentum, the hepatic artery being to the left. It is not quite two inches long; its diameter is one-fifth of an inch (4 mm.). Uniting with the cystic duct, it forms the *common bile duct* (ductus communis choledochus).

The **common bile duct** is about three inches in length. It passes down between the layers of the lesser omentum, in front of the portal vein, and to the right of the hepatic artery (fig. 584); it then passes behind the first part of the duodenum, then between the second part and the head of the pancreas, and ends at the lower part of the second segment of the duodenum by opening into that part of the intestine on its left side and somewhat behind (figs. 571, 586, and 587). It pierces the intestinal wall very obliquely, running between the muscular layer for about three-quarters of an inch. There is a slight constriction at its termination. The pancreatic duct is united with the common bile duct just before its termination. There is a slight papilla at their place of opening on the mucous surface of the duodenum. This papilla is about four inches from the pylorus. After the pancreatic duct has entered the bile duct there is a dilatation of the common tube called the **ampulla of Vater.**

The common duct has a diameter of about one-fourth of an inch (6 mm.). Its width at the ampulla is greater. It is narrowest at its outlet into the duodenum. The cystic and hepatic ducts are a little narrower than the common duct.

Structure of the gall bladder.—The wall of the gall bladder is made up of three coats—serous, muscular or fibrous, and mucous.

FIG. 586.—ABDOMINAL VISCERA, FROM BEHIND. (Rüdinger.)


LARYNX
GULLET
Aorta
BRONCHUS
LUNG
LUNG
Vena cava
DIAPHRAGM
LIVER
PANCREAS
DUODENUM
SPLEEN
STOMACH
Superior mesenteric vein
DESCENDING COLON
ASCENDING COLON
Inferior mesenteric vein

1. The *serous coat* being formed by the peritoneum, is only found on the lower surface and part of the sides. Beneath this coat is a nerve plexus.

2. The *fibrous coat* consists of plain muscular fibres and fibrous tissue. The muscular fibres run mostly longitudinally, some transversely. The fibrous tissue consists of white fibres running in every direction. This layer contains the principal blood-vessels and lymphatics, and also contains a nerve plexus.

3. The *mucous coat* is raised into rugæ bounding polygonal spaces, which are largest about the body. It is lined with columnar epithelium, and contains many mucous glands. At the neck the mucous membrane forms folds which project into the interior, acting as valves. This layer contains an anastomosis of blood-vessels, and a fine plexus of lymphatics.

The *ducts* consist of a fibrous and a mucous layer. In the fibrous layer are muscular fibres which are chiefly circular, together with many strong white connective tissue and elastic fibres. The mucous layer is lined with columnar epithelium, and has many mucous glands. In the cystic duct the mucous membrane is raised into folds, which are crescentic in form, and so directed obliquely as to seem to surround the lumen of the tube in a spiral manner.

Varieties of the Liver

Varieties are more rare in the liver than in almost any other organ of the body.

The left lobe may be very small; on the other hand, it may be much larger, occasionally extending in an attenuated form much more towards the left. The left lobe, or a portion of it, may be attached only by a pedicle of peritoneum and vessels to the main organ. The gall bladder has been seen through an opening in the upper surface, owing to the depth of the fossa of the gall bladder.

The liver may be subdivided into many lobes, or may show no division at all. It may retain the thick rounded form of the fœtus. The gall bladder may be absent, in which case the hepatic duct usually becomes much dilated before it reaches the duodenum.

The gall bladder may be partially divided either transversely or longitudinally. The common duct may enter the bowel independently of the pancreatic duct.

THE PANCREAS

The **pancreas** is situated in the epigastric and left hypochondriac regions. It is a compound racemose gland. It lies transversely across the body, on a level with the first and second lumbar vertebræ, and is deeply placed (fig. 577). It differs in shape as it is examined *in situ*, or removed from the body. When examined *in situ* it shows various impressions for the different organs with which it is in contact (figs. 570, 571); when removed from the body it appears to be longer, and runs to a point at the left extremity (fig. 587). It is of a pinkish-cream colour and soft in texture. It shows upon its surface the markings between the lobules of which it is made up. It may be divided into four portions: a head, a neck, a body, and a tail. The pancreas varies considerably in size. Its average length is five to six inches (120 to 150 mm.), and its thickness from half an inch to one inch. It weighs from 2½ to 3½ ounces. The **head of the pancreas** is situated at the right extremity of the gland, and is contained in the loop of the duodenum. It is disc-shaped and flattened from before backwards. The head is bent downwards, so that it extends lower than the lower border of the body. Behind it are found the common bile duct, which runs, as a rule, in a canal in its substance, the vena cava, the left renal vein, and the aorta (fig. 571). In front are the superior mesenteric vessels, the pancreatico-duodenal vessels, and the transverse colon and its meso-colon.

The **neck** springs from the upper part of the head in front and turns upwards and to the left to join the body. It lies over the point of junction of the superior mesenteric and portal veins. At its attachment to the head it is grooved by the gastro-duodenal and superior pancreatico-duodenal arteries. In front of it would be the first part of the duodenum.

According to Professor His, there are three surfaces on the **body of the pancreas**: anterior, inferior, and posterior. The body extends from the head of the gland to the spleen; it is situated transversely across the vertebral column with the large vessels intervening.

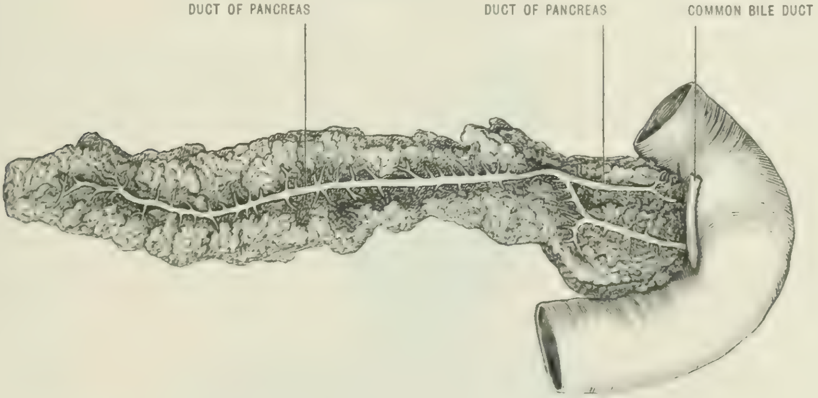
The *anterior surface* is in contact with the stomach, which organ gives a concavity to the surface (fig. 590). This surface is covered by peritoneum derived from the ascending layer of the transverse meso-colon.

The *posterior surface* is in contact with the crura of the diaphragm, the aorta, and superior mesenteric vessels, which structures are interposed between it and the spine (figs. 571, 586). The splenic artery and vein run lengthways above the back of the upper border of the posterior surface. To the left, the posterior surface is in contact with the left kidney and suprarenal capsule. The upper border in the middle line abuts against the cœliac axis.

The *inferior surface* is narrow, and lies over the fourth part of the duodenum and beginning of the jejunum. The transverse meso-colon is continued from the front of the head along the border separating this surface from the anterior surface. The splenic end of the transverse colon lies under the left extremity of this surface. From the under surface of the transverse meso-colon a layer of peritoneum passes to the central part of the inferior surface. The posterior surface is devoid of peritoneum.

The **tail of the pancreas** is the name given to the left extremity of the organ; it touches the lower part of the inner surface of the spleen.

FIG. 587.—THE PANCREAS AND ITS DUCT.



The **duct of the pancreas,** or the canal of Wirsung, white in appearance, runs from nearly the extreme left of the gland, concealed by the proper substance of the pancreas, nearer its posterior surface than the anterior, between the upper and lower borders, to empty into the lower and inner part of the second portion of the duodenum with the common bile duct. It runs sinuously, receiving its branches as it goes, which enter nearly at right angles. These branches are straight. Its diameter near its termination is one-tenth of an inch. The pancreatic duct often does not join the common bile duct until its termination, running side by side with it through the walls of the intestine. Occasionally the pancreatic duct opens by itself into the duodenum.

Blood-supply.—The pancreas receives blood from the splenic artery through its pancreatic branches, and from the superior mesenteric and hepatic by the inferior and superior pancreatico-duodenal arteries, which form a loop running round, below, and to the right of its head.

The blood is returned into the portal vein by means of the splenic and superior mesenteric veins.

Lymphatics.—The lymphatics terminate in two glands which lie on the superior mesenteric artery.

Nerves.—These are branches of the solar plexus which accompany the arteries entering the gland.

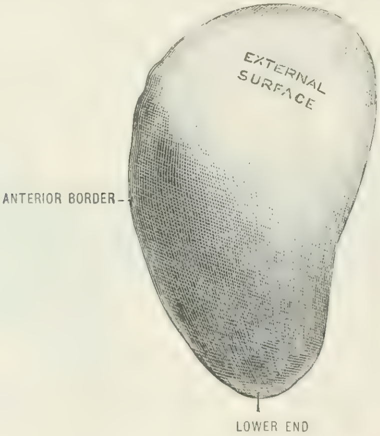
THE SPLEEN

Position.—The **spleen**—one of the ductless glands—is situated for the most part in the left hypochondriac region (figs. 577, 591). It is deeply placed between the fundus of the stomach and the diaphragm, and in the line of the axilla it extends between the eighth and eleventh ribs. It is covered by the ninth, tenth, and eleventh ribs (fig. 583), and is separated from them by the diaphragm, and to a smaller extent by the lung. Its upper end reaches to the level of the ninth thoracic spine, and its lower end to the level of the first lumbar spine. Its inner extremity is within two inches of the median plane of the body, and its outer boundary is posterior to the mid-axillary line. A line drawn from the left sterno-clavicular joint to the tip of the eleventh left rib bounds the anterior margin of the spleen.

It is bluish-red in colour, is soft, and easily lacerated.

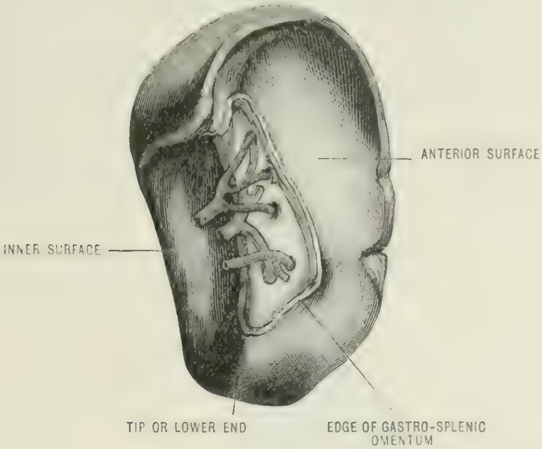
Its **shape** varies, and depends much upon the condition in which it is examined. If soft, and as usually found after removal from the body, it can only be said to have two surfaces, an outer convex and an inner concave; but if examined after it has been hardened *in situ*, after the manner of Professor His, it is seen to be of a much more precise shape, and to present three surfaces (fig. 590).

FIG. 588.—OUTER ASPECT OF THE SPLEEN.



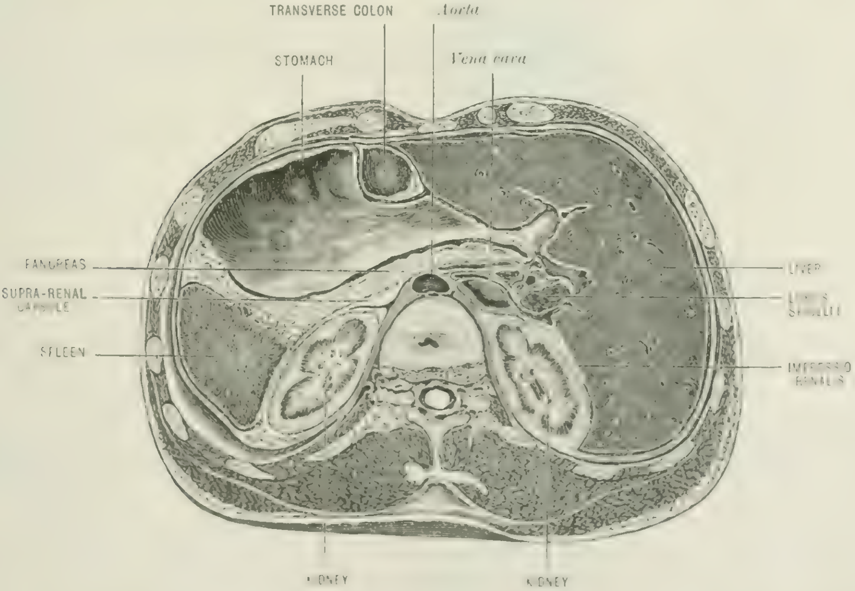
Viewed from the outside, it presents a form which is irregularly oval, wider above than below, with a bulging of the anterior border (fig. 588). The three **surfaces** are the external, anterior, and inner. The **external** or **posterior surface** is the largest. It is regularly convex, and is directed outwards and backwards and somewhat upwards (figs. 588, 590). It lies against the commencement of the arch of the diaphragm. It is covered by peritoneum. This surface is named by Cunningham the phrenic surface. It is separated by the peritoneum and diaphragm, and to some part of its extent by the pleura and lung from the eighth, ninth, tenth, and eleventh ribs. Viewed from the inside, the two other surfaces are seen to be divided by a distinct vertically directed ridge (fig. 590). The **anterior** of the two looks forwards, inwards, and a little downwards. It is concave from above downwards, and from side to side. It is a good deal the larger of the two, and is semilunar in shape (fig. 589). It is in contact with the great *cul-de-sac* of the stomach, with the tip of the pancreas, and the extreme point of the splenic flexure of the colon (fig. 586). This surface is named by Cunningham the gastric surface. Near the posterior border of this surface and bounded by the ridge is seen the hilum of the spleen, a depression running vertically from above downwards. It is here that the splenic artery and vein enter the gland, the vein being behind. In front of and behind the hilum is seen the attachment of the gastro-splenic omentum. The ridge separating this surface from the inner surface is well defined, and runs from the top of the spleen to the lower part of the posterior border.

Fig. 589.—Inner Aspect of the Spleen.


ANTERIOR SURFACE
INNER SURFACE
TIP OR LOWER END
EDGE OF GASTRO-SPLENIC OMENTUM

The **inner** or **renal surface** is much narrower and shorter than the anterior. It is only slightly concave in both directions. It is directed inwards and downwards, and is in relation with the outer border of the left kidney.

Fig. 590.—Transverse Section of the Body at the Lower Part of the Epigastric Region. (Rüdinger.)


TRANSVERSE COLON
Aorta
STOMACH
Vena cava
PANCREAS
SUPRA-RENAL CAPSULE
SPLEEN
LIVER
LOBUS SPIGELII
IMPRESSIO RENALIS
KIDNEY
KIDNEY

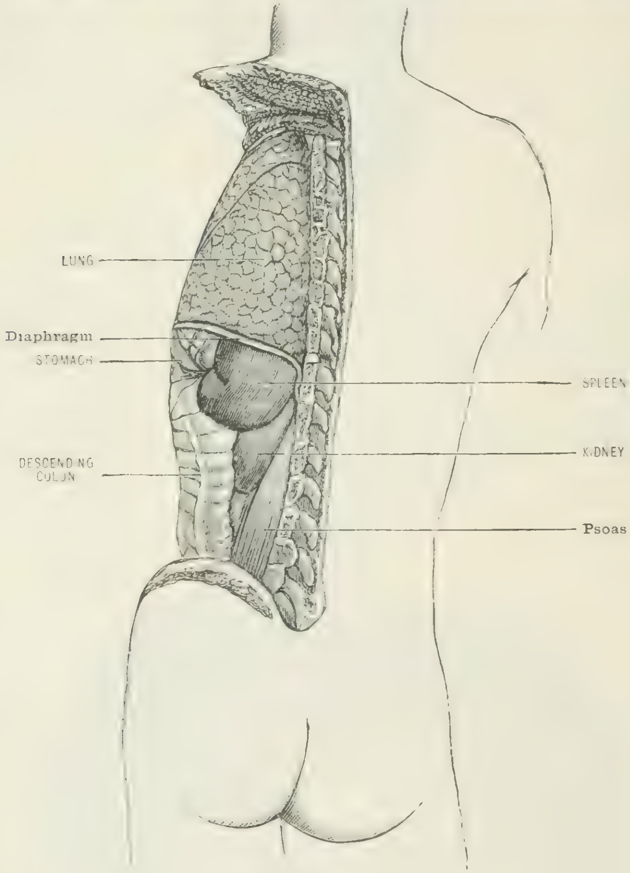
The **anterior border** of the spleen is more defined than the posterior, is sharper, and is marked by several notches, one of which is occasionally larger than the others. This border is convex. The **posterior border** is shorter and straighter. It separates the renal and phrenic surfaces. The term **inner border** is applied to the ridge between the gastric and renal surfaces.

The lower end of the spleen is blunt and presents a triangular area which Cunningham calls the basal surface. It lies against the splenic flexure of the colon and the costo-colic ligaments. The term basal applied to this extremity is due to the circumstance that the shape of the spleen *in situ* is that of an irregular tetrahedron with its base below (Cunningham).

The spleen is set obliquely in the body. Its long axis about corresponds to the line of the tenth rib.

In **size** it varies, owing to the fact that it increases in dimensions after food and under other circumstances. In the adult it measures generally about five to six inches in length, three or four inches in breadth, and one to one and a half inches in thickness; its usual volume, according to Krause, is from nine and three-quarters to fifteen cubic inches. Its average weight is one hundred and seventy grammes.

Fig. 591.—View of the Spleen, etc., from behind. (Rüdinger.)



It is entirely surrounded by peritoneum except at the hilum. On either side of the hilum the gastro-splenic ligament is attached. This reflexion of peritoneum, sometimes called the gastro-splenic omentum, passes inwards to the left extremity of the stomach and the left margin of the great omentum. A fold of peritoneum, the phreno-splenic ligament, connects the upper end of the spleen to the diaphragm. The reflection of peritoneum from the spleen to the left kidney is called the lieno-renal ligament.

Varieties.—The principal peculiarity is due to the presence of supplementary spleens (lienculi), found in the gastro-splenic omentum, or less often in the great omentum. From one to twenty of these small bodies may be met with. They are red and round, of the same structure as the spleen, and vary in size from a pea to a walnut.

Structure.—Beneath the covering of peritoneum is a thin but tough *capsule* of areolar tissue, called the tunica propria, which is very adherent to the serous membrane. It is remarkably elastic. It sends a prolongation in at the hilum, which follows and supports the vessels to their termination. Within the capsule is the *pulp*. This is a very soft friable tissue of a dark reddish-brown color, not unlike grumous blood in color and consistence. It can be squeezed out from the cut spleen, and then it will be seen that the whole organ is pervaded by a network of fine fibres which support the pulp. The larger of these come off directly from the fibrous capsule, and are called *trabeculæ*.

IN FRONT.
Stomach ; splenic flexure of colon.

OUTER SIDE.	GENERAL RELATIONS OF THE SPLEEN	INNER SIDE.
Diaphragm ; ninth to eleventh ribs between axillary line.		**Stomach ; pancreas ; left kidney and capsule.**

BEHIND.
Diaphragm.

Blood-supply.—The spleen receives its blood from the splenic artery, which is very large in proportion to the body it is going to supply. It divides before entering into about six branches. The artery is very tortuous. The vein, on the other hand, is straight, and lies below the artery.

The **lymphatics** are divided into a superficial and a deep set. The former forms a plexus beneath the peritoneum. The latter are derived from fine perivascular spaces in the adenoid tissue around the vessels. They join at the hilum, and pass between the layers of the gastro-hepatic omentum to the glands in that neighbourhood.

The **nerves** are from the solar plexus. They pass in along the splenic artery.

THE EVOLUTION OF THE PERITONEUM AND AN EXPLANATION OF ITS ARRANGEMENT IN THE HUMAN BODY

The peritoneum is a serous membrane, and is identical with other like-named membranes which are less complicated in their disposition. It differs in no essential particular from the pleura, from the pericardium, from the tunica vaginalis, from the synovial membrane of a joint, or from the simple vaginal sheath of a tendon. In all there is practically a closed sac of thin membrane, which is so disposed as to both line a cavity and to invest the structures which encroach upon that cavity.

Imagine a pleural cavity from which the lung had vanished without disturbance of parts. The membrane lining it would appear as a simple serous bag. Next conceive the lung gradually budding towards this sac. It would push the membrane before it, and as it did so it would both encroach upon the cavity lined by the membrane, and be itself covered or invested by it.

When the lung had attained nearly to the dimensions of the rigid cavity it was occupying, the serous lining would be found to invest the whole of it excepting only its pedicle—the stalk of the original bud—the root of the lung.

Although the thoracic space might be almost obliterated, the lung would still remain entirely outside the cavity of the serous sac. It would be convenient then to speak of the undisturbed layer which still lined the thoracic space as the *parietal layer*, and the layer which had come in a passive way to invest the lung as the *visceral layer*.

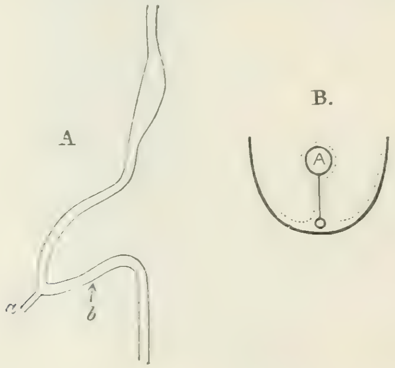
In the abdomen a similar condition exists. Imagine all the viscera to have vanished from the abdominal cavity. A great space would exist, bounded above by the diaphragm, below by the pelvic floor, and in front and behind by the abdominal parietes. This space would be evenly lined by the peritoneum in the form of a simple closed sac. As the viscera reappeared they would emerge, as it were, from the posterior wall of the belly, and would project into the cavity of the abdomen. In so doing they would push before them the peritoneum lining the posterior wall of the cavity, and would each in turn become invested by the displaced membrane. All the abdominal viscera are outside the peritoneal cavity, although they are obviously within the abdominal space. The peritoneal sac remains entirely empty, and its wall, with the exception of the Fallopian orifices, is unbroken.

That part of the simple sac which lines the anterior abdominal parietes is practically the only part which retains its original connections undisturbed.

One main function of a serous membrane is to minimise the effects of friction. Those viscera which are exposed to most movement, such as the small intestines, are the most completely invested by the smooth membrane; those which remain fixed, such as the kidney, are only casually invested. The movements of the viscera in respiration, the alteration in shape and position which will occur in such organs as the stomach and bladder, are provided for by the peritoneum in such a manner that these movements are practically without friction.

FIG. 592.—DIAGRAM OF THE PRIMITIVE ALIMENTARY CANAL.

(A : *a* indicates the vitello-intestinal duct ; *b* points to the future position of the cæcum.)



The viscera contained in the abdomen are not only numerous, but they are of very complex outline for the most part, and they are disposed in a manner which tends to greatly confuse their relations to one another.

A bare description of the peritoneum, as it is met with in the human subject, must needs be intricate and complicated, and if considered without reference to more primitive and simpler conditions is almost inexplicable. The description may be followed, but it needs interpretation, and no account of this membrane can be considered to be satisfactory unless it be rendered evident how the complex arrangement has come about, and unless the student base his conceptions upon the simple and rudimentary disposition which an elaborate development of parts and a remarkable specialisation of structure have rendered intricate and confusing.

The readiest idea of the disposition of the peritoneum is to be derived from a study of the development and most rudimentary forms of that membrane. Such a study is founded upon an examination of the human embryo at various periods, and of the peritoneum in the mammalia and lower animals.

The simple alimentary tube.—The alimentary canal first appears as a simple tube lying about the median line in front of the posterior abdominal parietes, and placed vertically. This tube is connected with the posterior parietes by a simple fold of peritoneum—a species of general mesentery (fig. 592).

The fact that the abdominal cavity is at an early period open in front, and that the rudimentary intestine protrudes beyond the limits of the future cavity may be disregarded. The cavity, such as it is, is lined by a membrane which is later recognisable as the peritoneum, and the general mesentery is produced by the growth and protrusion forwards of the elementary bowel from the tissues behind, i.e., outside the peritoneum.

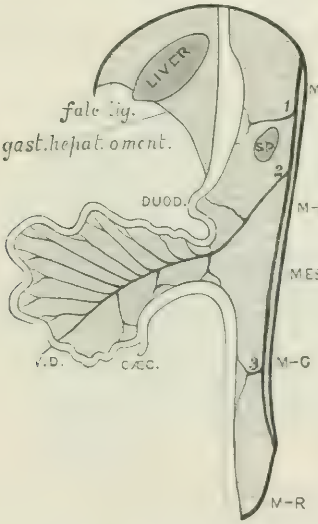
The simple straight tube, suspended on the posterior mesial line by its fold of peritoneum, becomes in due course differentiated (fig. 592).

The upper part becomes the stomach; the bowel immediately beyond forms the duodenum; then follow the small intestine; and lastly the colon and rectum.

The point of separation of the small bowel from the colon is indicated by the appearance of the cæcum.

It will be understood also that the upper part of the mesial peritoneal fold is called the meso-gaster (M-G, fig. 593); the next part the meso-duodenum (M-D); and the succeeding portions, in order, the mesentery, the meso-colon, and the meso-rectum (fig. 593, MES, M-C, M-R). The stomach becomes more distinctly marked; the tube below lengthens and forms an intestinal loop, which in the embryo projects beyond the site of the future umbilicus, taking the mesentery with it.

FIG. 593.—DIAGRAM OF THE PRIMITIVE ALIMENTARY CANAL.



This elementary condition of the intestinal canal persists in certain fully developed animals. As an example may be taken the alimentary canal of the salamander, as depicted in fig. 594. In this figure the viscera are shown undisturbed. In fig. 595, the peritoneum has been drawn forwards so as to show the parts in one median plane, and well represents the simple arrangement. In many mammals among the Edentates the simple vertical median fold of peritoneum is retained. This is shown in the great anteater, and in Hoffman's sloth (fig. 596), where the intestinal canal, from the pylorus to the rectum, is still quite simple, although it is of considerable length, and is, as a consequence, thrown into numerous coils. The whole of this long tube is supported by a single median fold of peritoneum attached to the middle line behind, and serving the purpose of meso-duodenum, mesentery, meso-colon, and meso-rectum in one.

Where this fold is attached behind, runs the aorta; and between the layers of the fold vessels pass forwards to supply the viscera. (Fig. 592, B, A, represents the intestinal tube to which an artery is passing.) There will be an artery to the stomach (1, fig. 593) and the great mesenteric artery. The latter vessel will supply the rudimentary duodenum, the small intestines, the cæcum, and such part of the colon as is later on known as the ascending and transverse segments. The arrangement of the vessel is shown in figs. 593, 2, and 596.

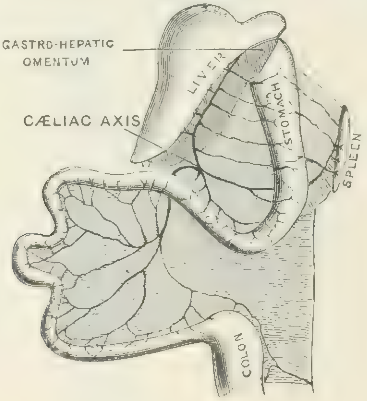
The descending colon and rectum are supplied by a separate vessel, the inferior mesenteric, direct from the aorta (3, figs. 593 and 596).

At the summit of the primitive loop which forms the principal part of the intestine will be the vitello-intestinal duct or vitelline stalk (v. d. fig. 593; *a*, fig. 592, A). It is to this point that the great or superior mesenteric artery is directed. The morphological ending of the superior mesenteric artery is at this spot, while branches pass off from either side of it. The student may be reminded that a trace of the vitelline duct may persist in the form of a process known as Meckel's diverticulum, and that this process, when existing, is situated in the lower part of the ileum not far from the cæcum (page 967). In the adult the trunk of the artery may be represented by a line drawn from its place of origin to a point on the ileum from one to three feet from the cæcum.

The primitive intestinal loop increases in length, and forms longer and more complex coils. A large part of these coils will lie without the abdomen, the anterior abdominal wall being still incomplete.

As the loop lengthens, a species of neck forms which tends to become narrower.

FIG. 594.—ALIMENTARY CANAL OF *SALAMANDRA MACULOSA*.



The upper part of this neck or strait is bounded or formed by the duodenum; the lower part by that portion of the large bowel which is at a later period known as the transverse colon (fig. 593).

The transverse colon and the duodenum are thus brought near together, and it is noteworthy that, no matter how complex the relations of the bowel become, these segments of the intestinal tube are never separated. In the narrow neck formed between them runs the trunk of the superior mesenteric artery. The great loop beyond this neck will form the small intestine, the cæcum, and the ascending colon. The descending colon retains its simple connections with the median line (fig. 593).

The mesentery does not increase in the same proportion as the intestines grow, and hence the bowel is thrown into innumerable convolutions. In the human subject the increase in the breadth of the mesentery is somewhat more noteworthy than its increase in length.

There is a time, then, when the great mass of the intestine is supported by a simple but extensive mesentery, which is entirely free, and which is attached behind by means of a narrow neck bounded by the duodenum and the right end of the transverse colon, and through which the superior mesenteric artery runs.

The great intestinal loop projects at first anteriorly and mesially. The small intestine is above, the large intestine below (figs. 593, 595).

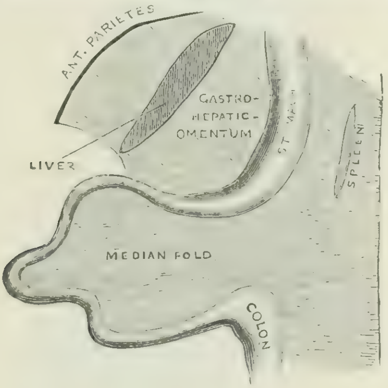
As the coils of bowel become more fully developed, it will be seen that all the small intestines lie to the right hand side, and the caecum and the commencement of the colon to the left. The vasa intestini tenuis of the superior mesenteric artery consequently arise from the right side of the vessel, while the ileo-colic, right colic, and middle colic all arise from the left (fig. 593).

Further development in this direction may not proceed, and the condition above described is met with in some of the lower mammals as a permanent arrangement (fig. 596).

The rotation of the intestinal canal.—As development proceeds, the plates which are forming the anterior abdominal parietes approach one another, and the closure of the cavity of the abdomen is imminent. The loops which have up to this time projected beyond the site of the future umbilicus are now withdrawn into the abdomen.

About this time a remarkable and quite characteristic rotation of the general mesenteric fold takes place. The rotation is from left to right, and is around an axis which may be represented by a line drawn from the neck or pedicle of the common mesentery to the site of the vitelline duct. This is in fact the line of the superior mesenteric artery (fig. 593). The rotation is therefore at the neck of the great and complex loop of intestine, which neck, as has been already said, is bounded by the duodenum and the right end of the transverse colon.

FIG. 595.—ALIMENTARY CANAL OF *SALAMANDRA MACULOSA*.



As a result of this rotation, the caecum and the ascending colon turn over to the right, while the great mass of the small intestines is brought to the left (fig. 597).

The lower end of the duodenum will consequently be carried to the left; the transverse colon will lie in front of it, instead of below it; and the superior mesenteric artery (2, fig. 597), which must still run between these two segments of the bowel, will now be described as passing over the duodenum, or as crossing its anterior surface. It is needless to say that in the fully-developed body this artery crosses the left end of the third part of the duodenum, and is behind the right end of the transverse colon. It will be seen that, in spite of this revolution, the duodenum and the transverse colon still retain their relations to one another, and still mark the neck or pedicle of attachment of the common mesenteric fold.

The effect of this rotation of the intestinal tube is shown in the diagram (fig. 597).

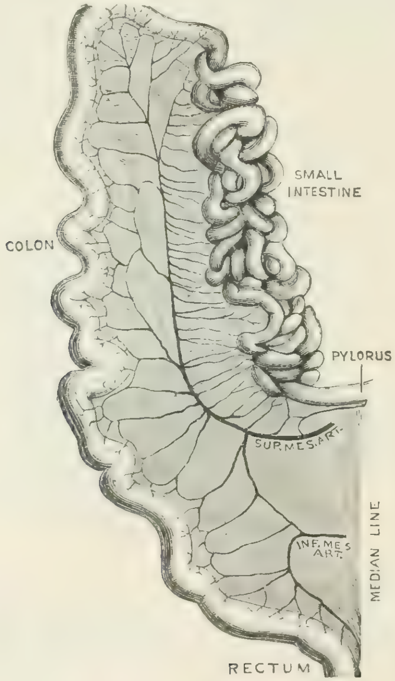
The caecum and ascending colon are now moved to the right; the transverse colon is more distinctly transverse; the small intestine has passed over to the left side. The right side of the mesentery has become the left side, and *vice versâ*; and the vasa intestini tenuis now appear to arise from the left border of the superior mesenteric artery instead of from the right (fig. 597). The duodenum is almost hidden from view, and has been brought into close contact with the vertebral column. The descending colon remains unchanged, and is supported by the still undisturbed median fold of the peritoneum.

The duodenum still has a meso-duodenum, and is still entirely invested by peritoneum.

In man further changes take place, but in mammals below man the condition just described is that which represents the normal arrangement. Fig. 597 may be considered to represent in diagrammatic fashion the simple intestine of a carnivorous animal.

In the human subject even development may not proceed beyond this point, and the condition detailed may be met with in the adult as a permanent arrangement. I have described some examples of this ('The Anatomy of the Intestinal Canal and Peritoneum in Man,' London, 1885; and 'Lancet,' Oct. 13, 1888). In these instances the whole of the small intestine, together with the cæcum and the ascending colon, were slung from a common mesentery, the attachment of which to the posterior parietes was by a narrow neck giving passage to the superior mesenteric artery, and bounded by the duodenum and the transverse colon. In these subjects there was no trace of the mesentery proper as it is found in the normal human body. The duodenum had been deprived of its meso-duodenum, and the descending meso-colon was comparatively scanty; but, with these and some minor exceptions, the resemblance of the arrangement of the bowels to that met with in the lower animals was very exact. It is the existence of this immature condition that predisposes to certain forms of twist or volvulus of the bowel.

FIG. 596.—ALIMENTARY CANAL OF *CHOLŒPUS HOFFMANNI.*



The progress of this rudimentary revolution of the intestinal tube may be noted by observing the progress of the cæcum.

That prominent diverticulum lies at first below the loop forming the lesser bowel, and then to its left side. It is at first without the abdomen, and is gradually withdrawn in the progress of development through the rapidly closing umbilical opening.

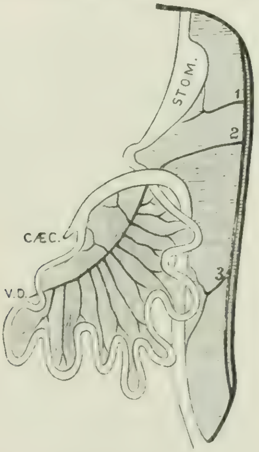
It then lies about the middle of the belly and just below the liver. Later, it passes to the right side, and then descends into the right iliac fossa.

It may be permanently arrested at any point of its course. In the condition known as the congenital umbilical hernia, the gap in the anterior abdominal parietes has never closed, and the protruding loop of bowel has never been quite withdrawn into the abdomen. The sac of such a hernia is made out of the tissues of the umbilical cord, and the contents are usually the caecum and lower part of the ileum, and not infrequently a Meckel's diverticulum. As has been mentioned already, the caecum may be found near the middle line or in the right hypochondriac region (page 971). It is then spoken of as undescended.

Final changes in the peritoneum.—Further changes in the position of the intestine and in the arrangement of the peritoneum are finally brought about, and these changes are almost entirely limited to the human subject. The intestine grows, and other abdominal viscera are encroaching upon the peritoneum. This membrane is mobile, is easily drawn from one point to another, and is capable of considerable adjustment. It does not, however, continue to grow at the same rate as the viscera which it serves to cover. The peritoneum is relatively more extensive in the fœtus than in the adult, and in the lower mammals than in man.

If the viscera grow out of proportion to the peritoneum, it is evident that the reflections of that membrane must here and there be shortened; and it is possible that a viscus which was at one time entirely covered by peritoneum may in due course become almost bared of it. This is so. In the diagram (fig. 598) a transverse section of the body is imagined, the section traversing the spot where the duodenum and transverse colon are in relation at the neck of the great common mesentery. Here, by reason of the rotation of the intestine from left to right, the mesenteric lamina has become folded upon itself (A, fig. 598). The fold would be V-shaped, open above, but coming to a point below. On transverse section the meso-duodenum (M-D) and transverse meso-colon (M-C) can be seen side by side. Now a constantly increasing demand upon the peritoneum is made by the rapidly growing viscera. The membrane is drawn in this direction and in that. There is some symmetry, however, within the abdomen, and the membrane may be conceived to be drawn equally upon in the direction of the arrows R and L.

FIG. 597.—DIAGRAM TO SHOW THE ROTATION OF THE INTESTINAL CANAL.



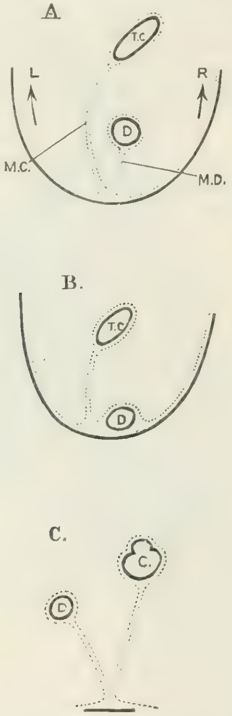
The result of such traction upon the peritoneum in this particular instance will be to lessen the length of the transverse meso-colon, and to use up the meso-duodenum altogether (fig. 598, B). That piece of bowel is indeed at last left uncovered by peritoneum behind, and is brought into contact with the posterior parietes. The serous membrane which formed the meso-duodenum has been utilised to afford a covering for adjacent viscera, which are increasing in size, and are pushing the peritoneum before them as they advance. In this particular region of the abdomen the growth of the liver, stomach, and spleen make great demands upon the adjacent peritoneum. As has been already said, it is evident that the growth of the general sac of the peritoneum does not keep pace with the growth of the structures it covers.

and that it is possible for one organ to be clothed with peritoneum at the expense of another.

To complete the account of the general relation of the peritoneum to the intestine, the following changes remain to be noticed:—

The meso-colon.—The descending colon is displaced by the growth of the rest of the bowel to the left side, and comes to occupy the position which it holds in the fully developed body. The primitive meso-colon is displaced also to the left, and survives as the descending meso-colon, the sigmoid meso-colon, and the meso-rectum (fig. 599). It may be so curtailed that no distinct fold that can be called a descending meso-colon is left, and the posterior part of the bowel is in such a case found to be more or less uncovered by the peritoneum. The meso-rectum is a genuine and but little disturbed relic of the simple median vertical fold of the primitive body.

FIG. 598.—DIAGRAM TO SHOW THE RELATION OF THE PERITONEUM TO THE DUODENUM.



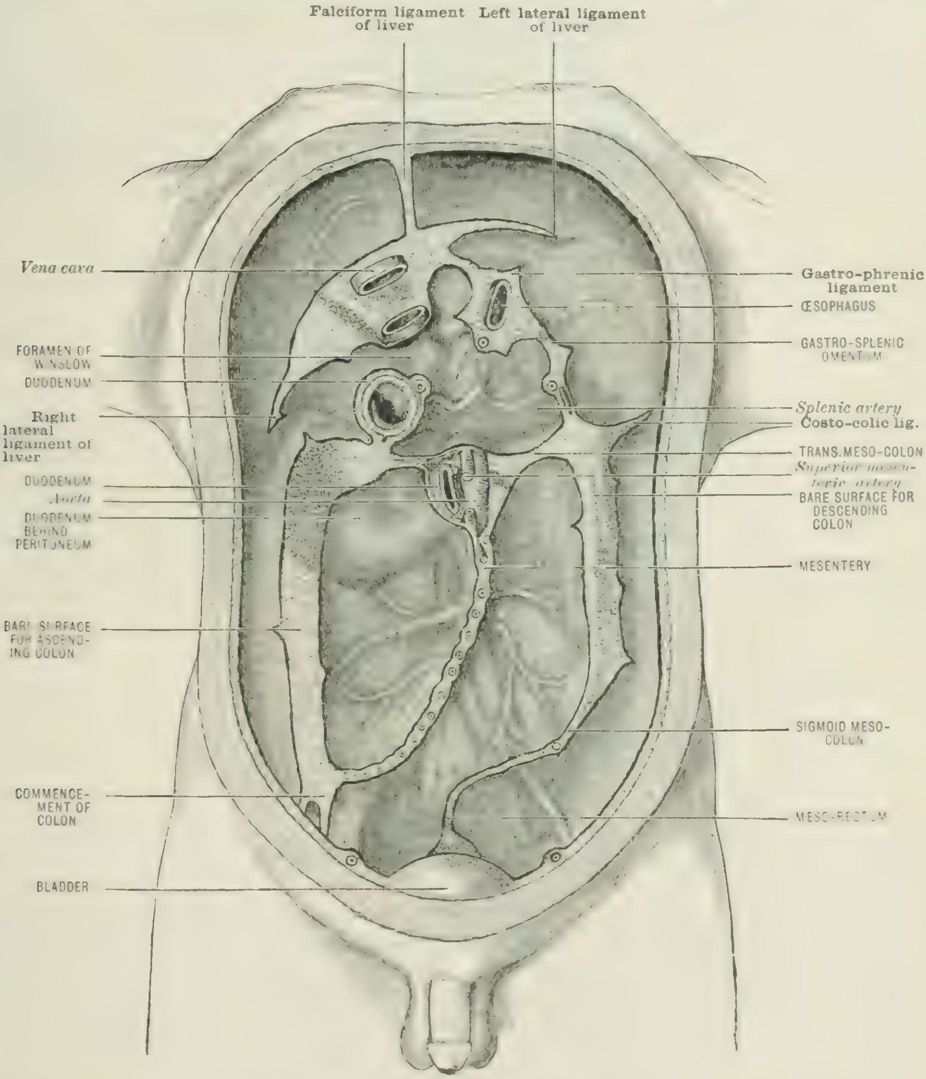
The duodenum is more or less bared of peritoneum, especially so far as its third part is concerned.

The ascending colon has, like the descending colon, been deprived of a considerable amount of its peritoneum. This membrane originally belonged to the common mesentery, but so much of it may have been abstracted from the bowel that this part of the colon may be free from peritoneum behind, or may be connected to the posterior parietes by a short meso-colon. The parietal attachments (so-called) of this ascending meso-colon are entirely acquired, and have no relation whatever to the primary attachment of the median fold—the primitive meso-colon —to the posterior wall of the abdomen (fig. 599).

The mesentery.—The mesentery proper—the fold belonging to the small intestines—in like manner and by a similar process acquires a new connection with the posterior parietes. In using the term 'new connection,' it must be understood that the sac of the peritoneum remains quite unbroken, and that the numerous duplicatures of the membrane have simply been so readjusted and displaced that it has in more points than one a reflexion from the posterior wall of the abdomen.

The mesentery is described as being 'attached posteriorly by a very short border which extends from the level of the attachment of the transverse meso-colon to the left of the middle line directly down to the right iliac fossa where the ileum falls into the cæcum' (Quain). This is the precise attachment made evident when the intestines have been all cut away, and nothing but the stump of the mesentery is left (fig. 599). The attachment is, however, wholly acquired or secondary, and has been brought about by an extensive readjustment of the peritoneum. The real attachment of the mesentery is about the origin of the superior mesenteric artery, and this attachment obtains in mammals below man. In fig. 599 is shown the posterior wall of the abdomen after the removal of the intestines, together with the stomach, liver, and spleen. The lines of the various peritoneal reflexions are depicted in a diagrammatic manner. A line drawn downwards, commencing at the falciform ligament of the liver, and continued past the œsophagus, through the gastro-splenic omentum, descending meso-colon, and sigmoid meso-colon,

FIG. 599.—DIAGRAM TO SHOW THE LINES ALONG WHICH THE PERITONEUM LEAVES THE WALL OF THE ABDOMEN TO INVEST THE VISCERA. (Cunningham.)


Falciform ligament of liver
Left lateral ligament of liver
Vena cava
FORAMEN OF WINSLOW
DUODENUM
Right lateral ligament of liver
DUODENUM
Aorta
DUODENUM BEHIND PERITONEUM
BARE SURFACE FOR ASCENDING COLON
COMMENCEMENT OF COLON
BLADDER
Gastro-phrenic ligament
ŒSOPHAGUS
GASTRO-SPLENIC OMENTUM
Splenic artery
Costo-colic lig.
TRANS. MESO-COLON
Superior mesenteric artery
BARE SURFACE FOR DESCENDING COLON
MESENTERY
SIGMOID MESO-COLON
MESO-RECTUM

represents the original attachment of the primitive median fold. All other lines of reflexion must be regarded as acquired or secondary.

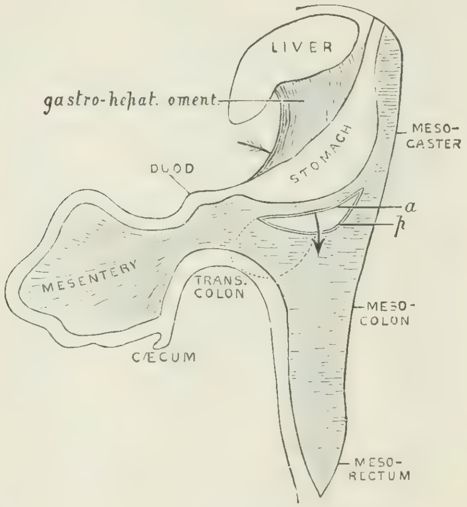
The meso-gaster.—It now remains to consider what becomes of the upper part of the simple primitive fold of peritoneum—the meso-gaster (M-G, fig. 593).

The stomach enlarges, assumes more of its characteristic outline, and becomes less vertical.

The liver may be regarded as an outgrowth from the duodenum. Its connections with the great veins of the heart cause it to extend upwards and to the right side. As it grows it separates the layers of the highest part of the peritoneal fold, and from this membrane it receives a covering. The remains of the primitive mesial fold persist in the form of the falciform ligament (figs. 593, 595, and 599).

The gastro-hepatic omentum.—The connection of the liver to the stomach is intimate, partly through the association of the great gland with the duodenum, and partly through certain blood-vessels which pass to the stomach and liver from the aorta. As the stomach enlarges, its duodenal end is drawn towards the right side; the viscus becomes transverse, the left wall becomes anterior, and the right posterior. The layer of peritoneum which stretches between the two organs is called the gastro-hepatic or lesser omentum. The right or free margin of this omentum was originally anterior, and the whole fold is directly derived, with but little disturbance of the membrane, from the upper part of the primitive meso-gaster (figs. 593, 595).

FIG. 600.—DIAGRAM TO SHOW THE FORMATION OF THE GREAT OMENTUM.



The great omentum.—The formation and disposition of the great omentum are a little difficult to follow in the adult human species, and the student's conception of the right character of this fold may be a little distorted by a study of certain diagrams which show the omentum from one point of view only. In mammals and in the human fœtus the disposition of the great omentum is readily appreciated.

This fold appears as a bulging of the meso-gaster forwards and to the left. When the stomach has assumed its final position, this bulging of the membrane is of course entirely in the direction forwards.

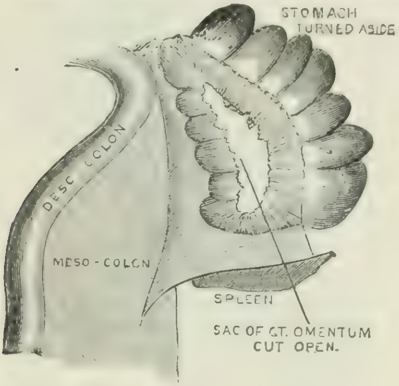
At first the great omentum forms a shallow and wide-mouthed bag. Its appearance is such as could be produced in imagination if the fingers were to be pressed against the right (posterior) side of the meso-gaster, and were to force a bag of the yielding membrane before them. The pendulous bag-like projection could be seen from the left side of the meso-gaster and the wide opening into the bag from the right (fig. 600). Here the bag is represented as cut away. An arrow passing from right to left, *i. e.*, from behind forwards, shows the direction of the protrusion.

The dotted line represents the position of the bag; *a* and *p* represent sections of its anterior and posterior walls.

The bag becomes larger and larger, and more and more pendulous, until it at last hangs down over the transverse colon and the small intestines as a kind of apron. Its orifice becomes narrowed in time by the growth of structures around it, and is known as the foramen of Winslow.

If the finger be introduced into this foramen, it will touch the posterior wall of the stomach, and consequently the right (or posterior) layer of the original meso-gaster. As both layers of the meso-gaster enter into the formation of this pouch or apron, it must of necessity be formed of four layers of peritoneum.

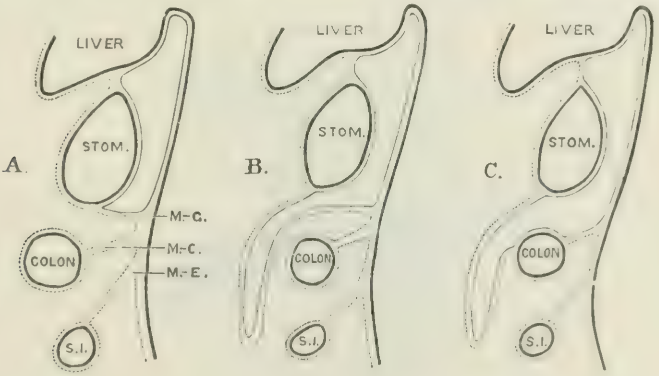
Fig. 601.—Great Omentum in *Macropus penicillatus.*



The place where the bulging takes place is a matter of importance. Originally such part of the meso-gaster is involved in it as extends from the region of the pylorus to about the middle of the fundus of the stomach (fig. 600).

In the lower mammals the rudimentary disposition of the great omentum is well seen. Thus in the two-toed anteater it may be observed in its simplest possible condition. It here takes the form of a slight bag projecting towards the left, and formed solely by that part of the primitive meso-gaster which is nearest to the greater curvature of the stomach. It extends to the right as far as the pylorus. It is quite horizontal. Its greatest depth does not exceed an inch, and its orifice is a wide, shallow opening upon the right side of the meso-gaster.

Fig. 602.—Formation of Great Omentum as seen in Vertical Section.



In higher mammals—as in some marsupials—the great omentum appears as a loose, pendulous, open bag, with so large an opening that it could not be termed a foramen. (Fig. 601 shows the great omentum in the kangaroo.)

In man and in most of the higher mammals not only is the meso-gaster (M-G, fig. 602, A) involved in the bulging which forms the great omentum, but some part of the transverse meso-colon (M-C) becomes involved also. This depends upon the close connection which exists between the right end of the transverse colon and the duodenum. It will be seen from figs. 600 and 602, A, that but a little extension of the bulging of the membrane is needed for the transverse meso-colon to become involved. In such case the anterior layer of the great omentum will appear to come off from the greater curvature of the stomach, while the posterior layer will return to the transverse colon and will become continuous with the meso-colon (figs. 602, C, and 603, A). In the adult man this arrangement usually extends throughout the greater part of the width of the great omentum. It is in all instances to be observed in all that part of the great omentum which is about and to the right of the middle line. In the fœtus (as in the lower primates) the posterior layer of that part of the great omentum which is quite to the left of the middle line is clear of the transverse meso-colon, and is obviously derived from the meso-gaster solely (figs. 602, B, and 603, B).

FIG. 603.—RELATION OF GREAT OMENTUM TO TRANSVERSE COLON.

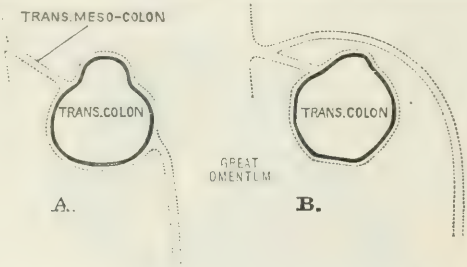
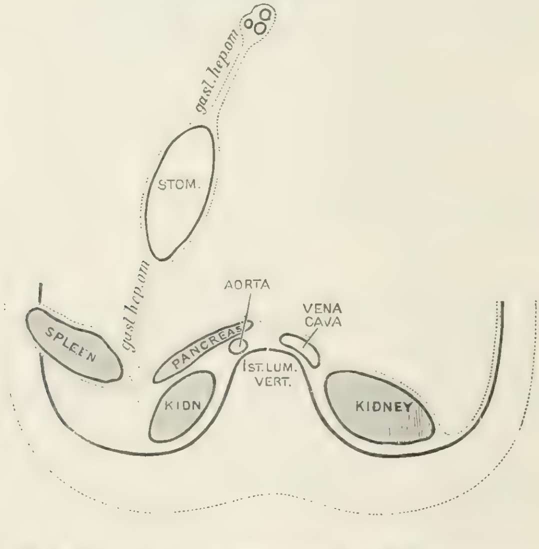


FIG. 604.—TRANSVERSE SECTION OF THE ABDOMEN AT THE LEVEL OF THE FORAMEN OF WINSLOW.

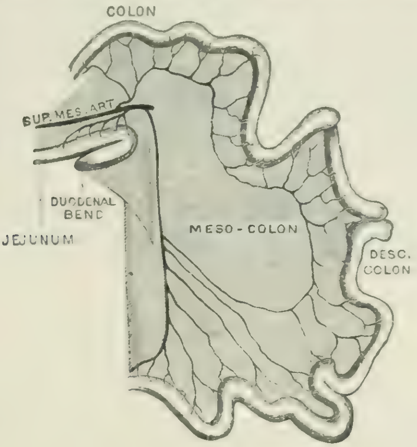


This difference between the right and the left extremities of the transverse meso-colon and omentum can sometimes be made out in the adult man.

The term 'the lesser cavity of the peritoneum' is applied to the cavity formed by this protrusion of the peritoneum. The term is of use for descriptive purposes, but it is apt to be misleading if it favors the impression that the general sac of the peritoneum is divided into two perfectly distinct parts.

If the diagram (fig. 562), which shows a transverse section of the abdomen at the level of the foramen of Winslow, be examined, it will be seen that the posterior layer of the gastro-hepatic omentum, the covering of the posterior wall of the stomach, the right layer of the gastro-splenic omentum, and the peritoneum over the pancreas, are all derived from this so-called lesser sac of the peritoneum. If one could imagine the stomach to be once more brought back to its original median position, some such appearance as is shown in fig. 604 would be presented.

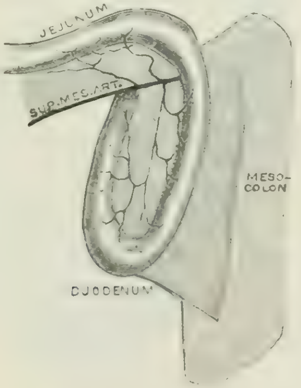
FIG. 605.—INTESTINE OF *MACROPUS PENICILLATUS.*



From this it will be seen that the gastro-splenic omentum, the coverings of the stomach, and the gastro-hepatic omentum are all derived from the original meso-gaster, the posterior attachment of which has been shifted considerably to the left. The left margin of the foramen of Winslow will then be seen to be the free anterior or ventral margin of this simple primitive fold.

The gastro-splenic omentum.—The spleen develops in the meso-gaster posterior to the stomach, and the gastro-splenic omentum is but a little altered part of the original membrane.

FIG. 606.—DUODENAL FOLD OF *MACROPUS PENICILLATUS.*



This relation of the spleen to the meso-gaster is very admirably demonstrated in some animals (figs. 593, 594, 595, and 601).

The **duodenal fold** is to be seen in the bodies of nearly all mammals below man, excluding those somewhat lower species in which the intestinal tube remains still as a median loop (pages 993, 994).

If figs. 593, 597, and 598 be examined, it will be understood that when the rotation of the intestine takes place and the colon rises up and crosses in front of the duodenum, the peritoneum between the meso-duodenum and meso-colon must be folded upon itself. The folding is V-shaped, the apex of the V being placed below, and the plication being in or about the median line. The two membranes on a transverse section would have the relation to one another shown in fig. 598, C.

The third part of the duodenum is brought closer to the posterior parietes; the peritoneum in connection with it is curtailed; and the relations of the structures around are readjusted. As a result of these changes, which can be followed in many of the lower mammals, a distinct fold is produced which is connected with the third and terminal parts of the duodenum, and is often of considerable size. This fold can be well studied in *Macropus*. It appears to come off from that margin of the bowel which is immediately opposite to the attachment of the meso-duodenum (figs. 605, 606). It ends below in a free edge, and posteriorly it either joins the peritoneum on the posterior parietes close to the origin of the descending meso-colon, or it joins the meso-colon at some little distance from the spine.

The traction about this somewhat firmly held segment of bowel has been such that it has been drawn between the layers of its own meso-duodenum. It is by this fold that is formed the wall of the fossa duodeno-jejunalis (page 966, fig. 572).

SECTION IX

THE URINARY AND REPRODUCTIVE ORGANS

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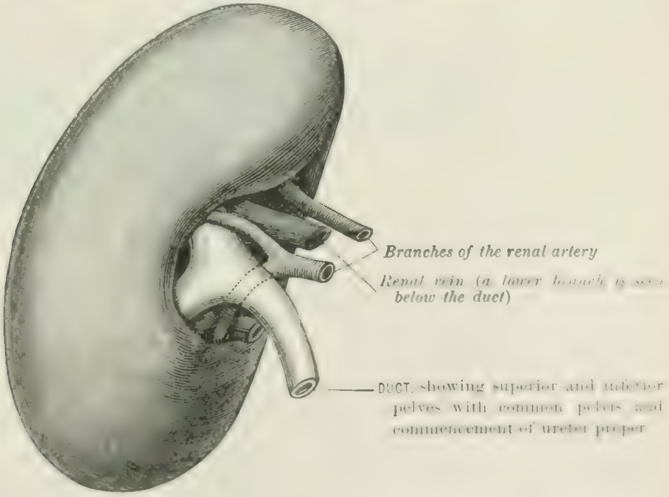
THE KIDNEYS

THE fundamental elements of the urinary apparatus are the **kidneys**—two glandular organs situated in the loins behind the peritoneum, each of which is provided with a duct—the **ureter**—for the passage of the secretion to a reservoir—the **bladder**—by which it is periodically expelled from the body through a tube of outlet—the **urethra.**

FIG. 607.—POSTERO-INTERNAL ASPECT OF THE LEFT KIDNEY.

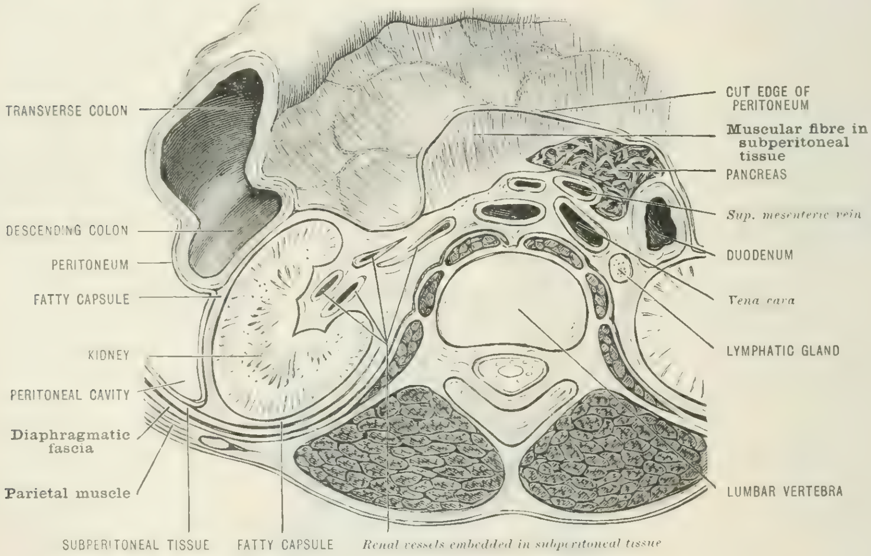

Branches of the renal artery
Renal vein (a lower branch is seen below the duct)
DUCT, showing superior and inferior pelves with common pelvis and commencement of ureter proper

Physical characters.—The kidney in its typical form is bean-shaped. It is elongated from above downwards, compressed between its parietal and abdominal surfaces, and presents at its anterior and internal aspect a cleft, the **hilum,** leading to a cavity, called the **sinus,** in which lie the renal vessels, nerves, and duct. The gland in the male averages about four and three-quarter inches (12 cm.) in length, an inch and an eighth in thickness, and weighs about five ounces. The dimensions of the female kidney differ little from those of the male, but its weight is from one-seventh to one-fifth less. In the child the organ is relatively large, but its permanent relation to the body-weight is usually attained at the end of the tenth year of life.

It offers for description two surfaces, two extremities, and two borders. The **anterior** or **visceral surface** is convex, and looks obliquely forwards and outwards; the **posterior** or **parietal surface**, less convex than the anterior, looks inwards and backwards; the rounded **upper extremity** is usually somewhat larger than the lower, and is placed about half an inch nearer to the median sagittal plane of the body. The **external border** is narrow and convex. The **internal border** (or surface), looking forwards, inwards, and slightly downwards, is relatively broad, and is fissured vertically in the middle third of its length by the hilum.

The **hilum** is a slit-like aperture bounded in front and behind by two rounded lips of variable and unequal thickness. The posterior lip is nearer to the middle line than the anterior, and between the two pass the renal vessels and nerves, the duct, and a quantity of fat-bearing connective tissue. The **sinus** (fig. 609), occupied by the structures just named, is narrowest near its entrance, and about an inch (25 mm.) in depth. Its fundus is pierced by the renal vessels and nerves, and by the uriniferous tubules; and gives attachment to the primary branches (**calices**) of the duct.

FIG. 608.—DIAGRAM SHOWING RELATION OF KIDNEY TO CAPSULE. (W. A.)


TRANSVERSE COLON
DESCENDING COLON
PERITONEUM
FATTY CAPSULE
KIDNEY
PERITONEAL CAVITY
Diaphragmatic fascia
Parietal muscle
SUBPERITONEAL TISSUE
FATTY CAPSULE
Renal vessels embedded in subperitoneal tissue
CUT EDGE OF PERITONEUM
Muscular fibre in subperitoneal tissue
PANCREAS
Sup. mesenteric vein
DUODENUM
Vena cava
LYMPHATIC GLAND
LUMBAR VERTEBRA

Investment and fixation.—The entire organ is enveloped and supported by a kind of capsule of fat-bearing connective tissue derived from the parietal layer of the subperitoneal fascia (fig. 608). The adipose element is usually small at birth, but tends to increase about puberty and during adult life. When it is scanty, the subperitoneal investment often appears as a transparent fascial plane, which in renal operations may be mistaken for peritoneum or fascia transversalis; or if the fat be excessively developed over the posterior aspect of the organ, it may form a kind of hernial protrusion into the parietal incision. Should the sustentacular power of the fatty capsule become impaired by atrophy from wasting disease, by the pressure of a pregnant uterus or tight stays, or from any other cause, the phenomenon of movable or wandering kidney may be set up by slight external violence, the organ tending to shift its place as far as the attachment of its vessels to the main trunk will permit.

Position and relations.—The kidney is commonly said to lie in the lumbar region. It is, however, intersected by the horizontal and vertical planes which separate the hypochondriac, lumbar, epigastric, and umbilical regions from each other, and hence belongs to all these segments of the abdominal space. Its

Fig. 609.—Section of Kidney showing the Sinus. (After Henle.)

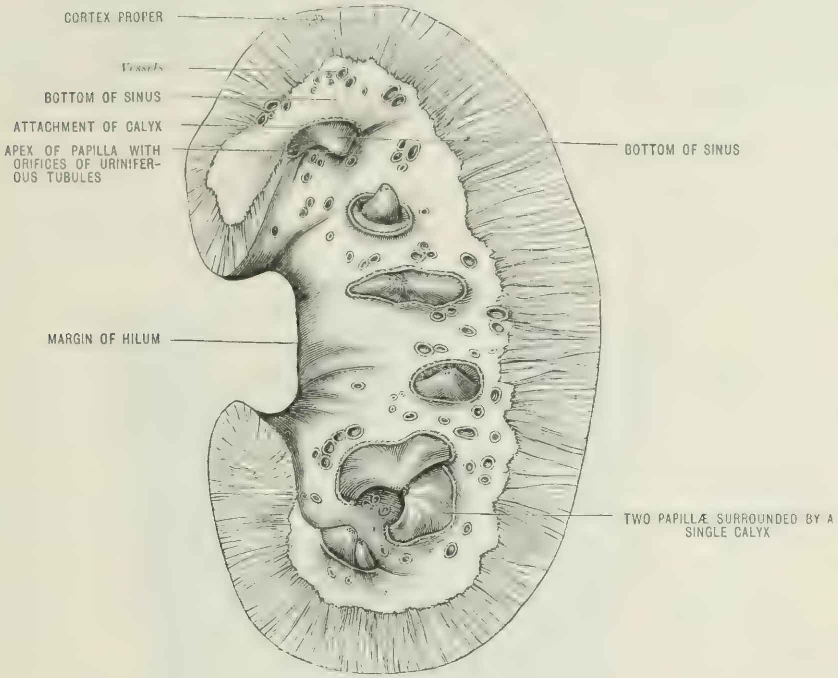
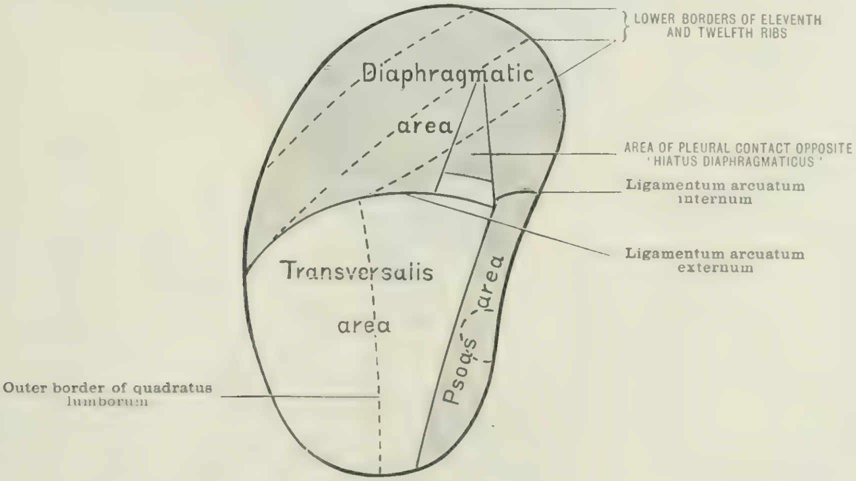

CORTEX PROPER
Vessels
BOTTOM OF SINUS
ATTACHMENT OF CALYX
APEX OF PAPILLA WITH ORIFICES OF URINIFEROUS TUBULES
BOTTOM OF SINUS
MARGIN OF HILUM
TWO PAPILLÆ SURROUNDED BY A SINGLE CALYX

Fig. 610.—Diagram of Relations of Posterior Surface of Left Kidney.


LOWER BORDERS OF ELEVENTH AND TWELFTH RIBS
Diaphragmatic area
AREA OF PLEURAL CONTACT OPPOSITE 'HIATUS DIAPHRAGMATICUS'
Ligamentum arcuatum internum
Ligamentum arcuatum externum
Transversalis area
Psoas area
Outer border of quadratus lumborum

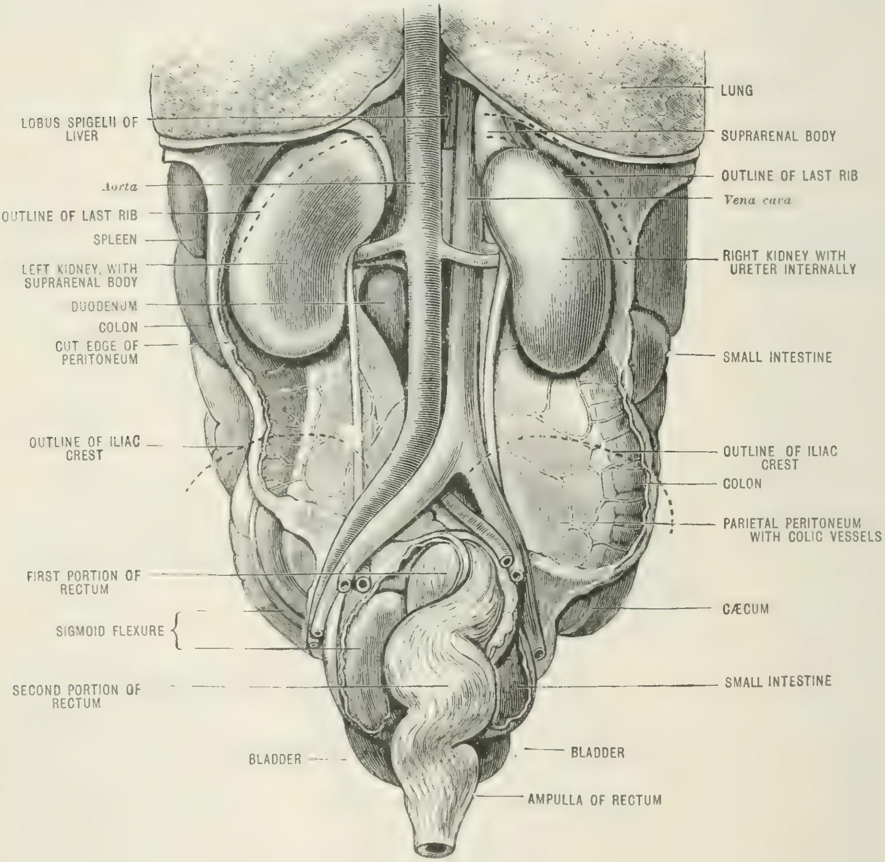
vertical level may be said to correspond to the last thoracic and two upper lumbar vertebræ, the right lying in most cases from a third to half an inch lower than the left, but exceptions to this rule are not unfrequent.

The **posterior surface** (figs. 610, 611), with the corresponding portion of the fatty capsule, rests against the posterior abdominal wall, extending upwards in front of the eleventh and twelfth ribs and inwards to overlap the tips of the transverse processes of the first and second lumbar vertebræ; the left kidney usually reaching as high as the upper border of the eleventh rib, the right only to its lower border. The only visceral relation posteriorly is on the left side, where the spleen slightly overlaps the kidney opposite the upper half of its outer border. The parietal relations on both sides are as follows: (1) the diaphragm, and if a well-marked *hiatus diaphragmaticus* exist above the ligamentum arcuatum externum, the kidney may come into relation with the subpleural tissue and pleura; at this point the chest may become invaded by a circumrenal abscess, or an empyema may find its way from the pleura into the subperitoneal tissue behind the kidney; (2) the anterior lamella of the posterior aponeurosis of the transversalis (separating the organ from the quadratus lumborum; (3) the psoas; (4) the three fasciæ—diaphragmatic, transversalis, and iliac—which line these muscles respectively; and (5) the last thoracic, the ilio-hypogastric, and the ilio-inguinal nerves, and the anterior divisions of the first and second lumbar vessels, all running obliquely downwards and outwards in front of the quadratus lumborum to pierce the transversalis beyond the outer border of the quadratus. Owing to the higher level of the left kidney, its diaphragmatic area of contact is larger than that of the right organ. This area, moreover, may be increased on either side when the arcuate

Fig. 611.—The Abdominal Viscera, seen from behind.

(From the model of His.)

The kidneys are somewhat lower than usual in their relations to the ribs.


LOBUS SPIGELII OF LIVER
Aorta
OUTLINE OF LAST RIB
SPLEEN
LEFT KIDNEY, WITH SUPRARENAL BODY
DUODENUM
COLON
CUT EDGE OF PERITONEUM
OUTLINE OF ILIAC CREST
FIRST PORTION OF RECTUM
SIGMOID FLEXURE
SECOND PORTION OF RECTUM
BLADDER
LUNG
SUPRARENAL BODY
OUTLINE OF LAST RIB
Vena cava
RIGHT KIDNEY WITH URETER INTERNALLY
SMALL INTESTINE
OUTLINE OF ILIAC CREST
COLON
PARIETAL PERITONEUM WITH COLIC VESSELS
CÆCUM
SMALL INTESTINE
BLADDER
AMPULLA OF RECTUM

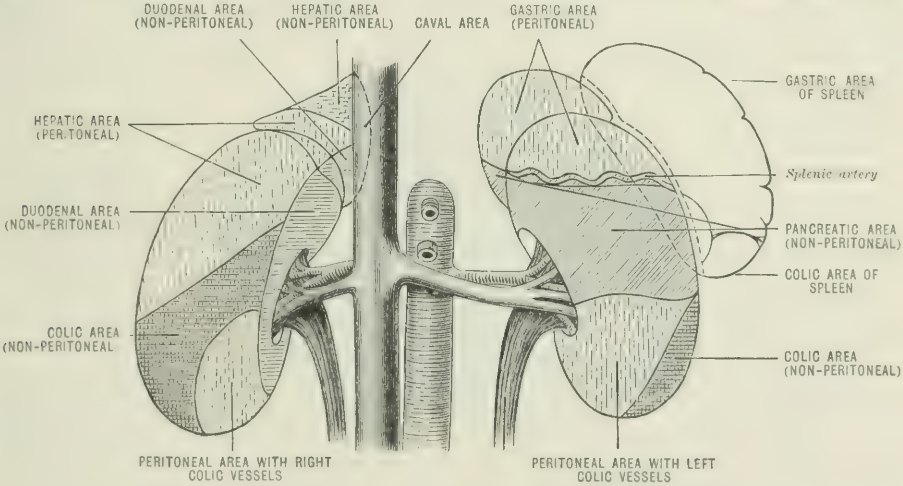
ligaments, which give origin to a large portion of the posterior fibres, are attached to the tip of the transverse process of the second lumbar vertebra instead of that of the first.

The pleura has an indirect but important relation to the kidney besides the more direct relation at the 'hiatus diaphragmaticus' referred to above. The inferior limit of the pleural sac extends almost horizontally outwards from the lower border of the twelfth thoracic vertebra, crossing the last rib near its neck, and the eleventh rib about two inches farther outwards. As a rule, the incision in renal operations may be carried safely to the lower border of the last rib; but, should this bone be absent or very short, the eleventh rib may be mistaken for it, and the serous membrane would then be in danger. It is probable, too, that the pleura reaches to a lower point in those cases where the arcuate ligaments are attached to the second lumbar transverse process. The presence of a thirteenth rib would involve a contraction of the space available for the surgical exploration of the organ.

The **upper extremity** of each kidney is crowned by the suprarenal body (figs 611, 612), which encroaches also upon its anterior surface and inner border, and is fixed to it by connective tissue derived from the subperitoneal fascia.

The **anterior or visceral surface** (fig. 612) is moulded to the contiguous organs. The *right* kidney is in contact in about its upper half with the renal impression on the liver (page 978), and below with the ascending colon and duodenum; the hepatic area being covered with peritoneum, while the second stage of the duodenum and more externally the ascending colon are directly attached to the surface by subperitoneal tissue; but the two non-peritoneal areas vary considerably in their relative proportions, not only in different subjects, but in the same subject under different conditions of distension of the duodenum and the colon. The second stage of the duodenum is also more or less in relation with the right renal vessels.

FIG. 612.—DIAGRAM SHOWING ANTERIOR RELATIONS OF KIDNEYS AND SUPRARENAL BODIES.


DUODENAL AREA (NON-PERITONEAL)
HEPATIC AREA (NON-PERITONEAL)
CAVAL AREA
GASTRIC AREA (PERITONEAL)
GASTRIC AREA OF SPLEEN
HEPATIC AREA (PERITONEAL)
Splenic artery
DUODENAL AREA (NON-PERITONEAL)
PANCREATIC AREA (NON-PERITONEAL)
COLIC AREA OF SPLEEN
COLIC AREA (NON-PERITONEAL
COLIC AREA (NON-PERITONEAL)
PERITONEAL AREA WITH RIGHT COLIC VESSELS
PERITONEAL AREA WITH LEFT COLIC VESSELS

The *left* kidney lies behind the stomach, the pancreas, the splenic vessels, the descending colon, and the colic vessels. Its anterior surface may be divided into three portions: an **upper** or **gastric area**, separated from the stomach by the peritoneum of the lesser sac; a **middle** or **pancreatic area**, attached to the pancreas by subperitoneal connective tissue, and crossed also by the splenic vein behind the upper border of the pancreas, and by the splenic artery, which runs in a serpentine course immediately above the vein; and an **inferior** or **colic area**, the outer portion of which is covered by the splenic flexure and upper part of the descending colon; the inner by a layer of peritoneum (of the greater sac) and the colic vessels.

The **outer border** of the kidney reaches a point about three and a half or four inches external to the lumbar spinous processes. On the right side, it is in contact with the liver in its upper half or two-thirds; on the left, its upper third or half rests against the renal groove in the posterior portion of the visceral surface of the spleen.

The **inner border** of the right kidney approaches very close to the vena cava, especially above; that of the left is divided from the aorta by an interval of an inch or more.

The position of the kidneys at the back of the abdominal cavity involves a certain amount of pressure upon the organs and their vessels and nerves by the weight of the viscera in front when the body is supine, and there is reason to believe that their secretory functions are consequently influenced by changes of posture to an extent that may be utilised in therapeutics.

The **structures lying within the sinus** are the renal artery and vein, the renal lymphatics (vessels and glands), a plexus of nerves, the duct, and more or less connective and adipose tissue continuous with the fatty capsule. The *renal artery* is a branch of the aorta given off opposite the first lumbar vertebra and behind the pancreas. On reaching the hilum it usually breaks up into four branches, three of which pass in front of the pelvis to supply the superior, middle, and inferior zones of the organ, while a fourth runs behind the pelvis close to the posterior lip of the hilum and is distributed over the lower half or two-thirds. This may be wounded in an attempt to remove a calculus by incision of the posterior wall of the pelvis. Besides these, irregular vessels may pierce the gland above or below the hilum (fig. 607). The *left renal vein* receives the spermatic or utero-ovarian vein, and is usually somewhat lower than the right. The shortness of the *right renal vein* should be remembered in the operation of nephrectomy.

Structure.—The kidney when removed from its fatty investment is seen as a yellowish-red organ covered by a thin but strong fibrous capsule (**tunica propria**), which is prolonged through the hilum into the sinus, where it becomes continuous with the sheaths of the renal vessels, and extends as far as the attachments of the subdivisions of the duct around the renal papillæ. The whole capsule may be easily peeled off from the healthy kidney, except at the bottom of the sinus, where it is fixed by the vessels and duct; and as the capsular vessels are of small size, the process of stripping is attended with little hæmorrhage when practised in the course of operations upon the living subject.

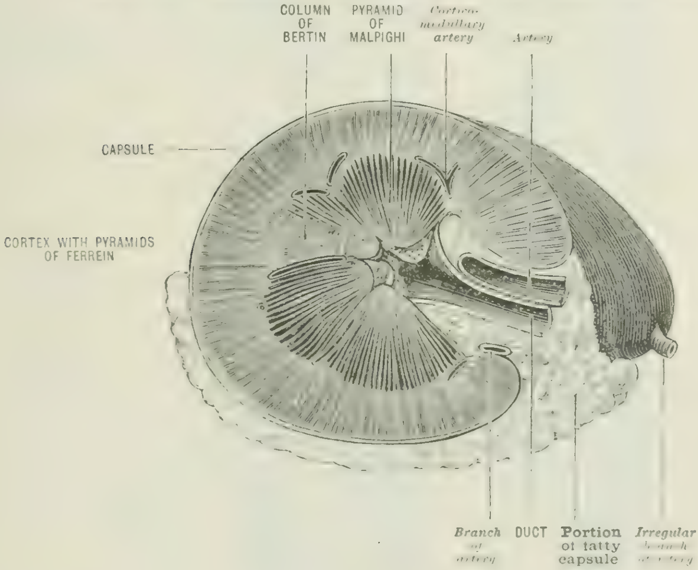
On section through the kidney, its substance is found to comprise an external or *cortical* and an inner or *medullary* segment. The **medulla** consists of a variable number (eight to eighteen) of conical segments called **pyramids of Malpighi**, the apices of which project into the bottom of the sinus (fig. 609) and are surrounded by the primary segments (**calices**) of the duct, while their bases are turned towards the surface, but are separated from it and from each other by the **cortex.** The **pyramids** average in their axial diameter about three-quarters of an inch, and have a width at the base of about two-thirds of an inch (16 mm.). They are smooth and somewhat glistening in section, and marked with delicate striæ which converge from base to apex, and indicate the course of the uriniferous tubules. The blunted apex, or **papilla,** single or blended with one or even two of its fellows, is embraced by a **calyx,** and if examined with a hand lens will be seen to present a variable number (twelve to eighty) of minute apertures, the **foramina papillaria,** through which the secretion escapes into the duct.

The **cortex** may be divided into two portions: a peripheral layer, the **cortex proper,** which is a little less than half an inch (12 mm.) in thickness, and extends from the capsule to the bases of the pyramids of Malpighi; and processes called **columns of Bertin,** which dip inwards between the Malpighian pyramids to reach the bottom of the sinus, where they are covered by the fibrous capsule and more or less adipose tissue (fig. 613). In section the cortex is somewhat granular in aspect, and in an injected kidney is seen to be dotted with minute points corresponding to vascular glomeruli lying within the cæcal origin of the uriniferous tubules (capsules of Bowman). Examined more closely, it displays a number of small pyramidal groups of tubules, some belonging to the cortex proper, with their bases resting upon the bases of the Malpighian pyramids, the apices directed towards, but not reaching, the periphery; others forming a part of the columns of Bertin, and disposed almost at right angles to the last. These cortical groups are called **pyramids of Ferrein,** in contradistinction to the much larger medullary pyramids of Malpighi.

The kidney of a fœtus differs from that of the adult in the lobular subdivision of its surface, each lobule corresponding to the base of a pyramid of Malpighi capped by a thin layer of cortex. Such a condition is permanent in some of the lower animals; but in man the superficial indications of morphological segmentation usually become obliterated during the progress of growth of the cortical tissue, and are seldom visible after the age of ten.

Uriniferous tubes (fig. 614).—The secreting tubules commence by a number of spherical capsules (**capsules of Bowman**), which lie in the cortex. From each capsule passes a tube with a narrow neck, which becomes wide and convoluted, then, narrowing again, runs down into the subjacent Malpighian pyramid, forms a loop (**looped tube of Henle**), returns into the cortex, where it again becomes dilated and contorted, and, after undergoing a final constriction, opens into a straight **collecting tube,** the axial element of a pyramid of Ferrein. The collecting tubes run into the Malpighian pyramids, and unite with each other to form a smaller number of larger tubes, which terminate by opening on to the papillary apex of the pyramid, and into the corresponding calyx of the duct. The tubes are lined with epithelium throughout, the cells being tesselated in the capsule, irregularly cubical in the convoluted tubes, flattened on the loops of Henle, and columnar in the cortical collecting tubes and in the straight tubes of the medulla.

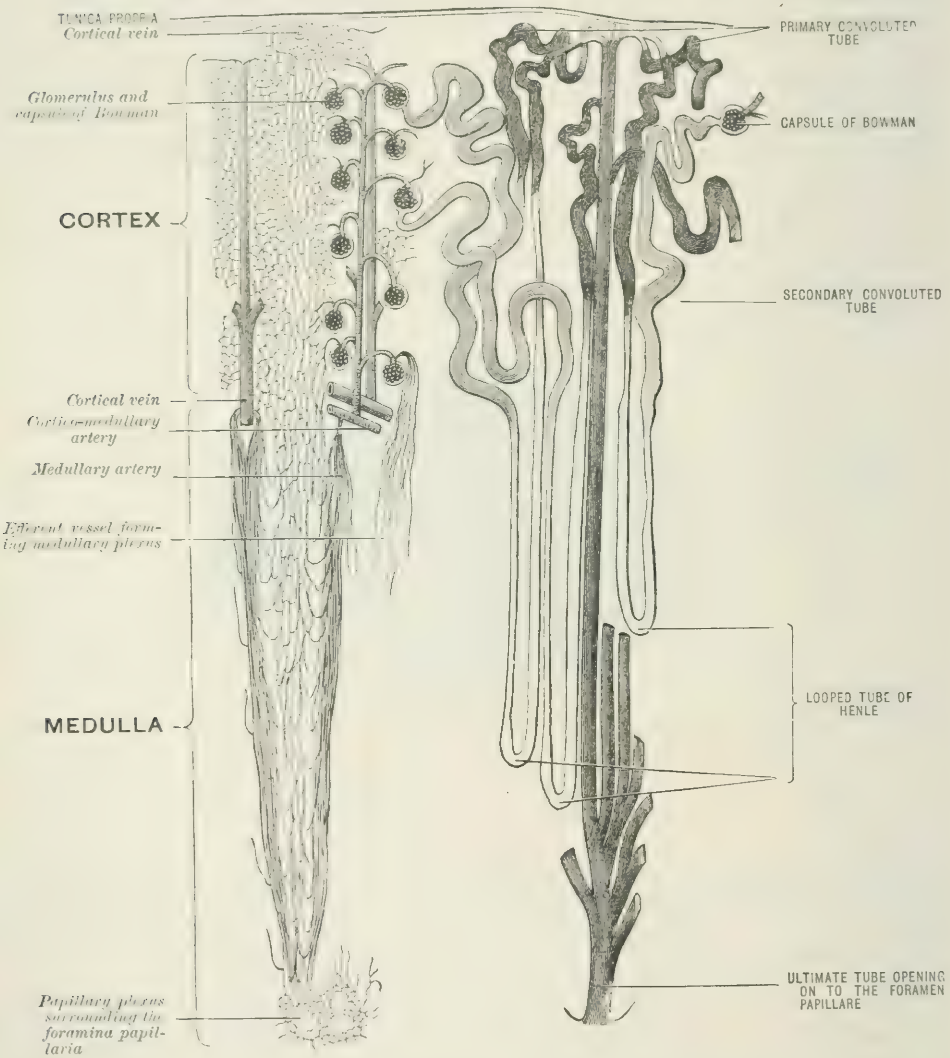
FIG. 613.—HORIZONTAL SECTION OF KIDNEY, SHOWING THE SINUS.



Vessels (fig. 614).—The kidney is very vascular. The larger arterial branches, if traced in section from the point at which they pierce the bottom of the sinus, will be found to run up between the pyramids of Malpighi to subdivide at their bases into **cortico-medullary arches** which lie between the cortex and medulla, giving off arterioles in both directions, the **cortical branches** supplying afferent twigs to the glomeruli within the capsules of Bowman: the **medullary** branches running inwards to form plexuses around the straight and looped tubules of the Malpighian pyramids. The **efferent vessels** of the Malpighian glomeruli form a capillary plexus around the uriniferous tubules and terminate in the renal veins. The surface of the kidney receives small collateral arteries which pass through the fatty capsule from the suprarenal, spermatic, and lumbar vessels. The superficial veins appear in the form of little stellate groups (**stars of Verheyen**), which communicate with the venous plexus in the adipose capsule and by means of this with the visceral and parietal veins in the neighbourhood. They are very distinct when the organ is congested. The renal **lymphatics** may be divided into two sets, capsular and parenchymatous. They terminate in a series of glands lying with the renal vessels in the subperitoneal tissue, and their contents are ultimately conveyed into the receptaculum chyli.

Nerves.—The nerves form a plexus accompanying the vessels, and are derived mainly from the sympathetic through the solar and aortic plexuses, and the splanchnics. They communicate with the spermatic plexuses. Some filaments have also been traced from the pneumogastrics.

FIG. 614.—SCHEME OF TUBULES AND VESSELS OF THE KIDNEY.


TUNICA PROPRIA
Cortical vein
Glomerulus and capsule of Bowman
CORTEX
Cortical vein
Cortico-medullary artery
Medullary artery
Efferent vessel forming medullary plexus
MEDULLA
Papillary plexus surrounding the foramina papillaria
PRIMARY CONVOLUTED TUBE
CAPSULE OF BOWMAN
SECONDARY CONVOLUTED TUBE
LOOPED TUBE OF HENLE
ULTIMATE TUBE OPENING ON TO THE FORAMEN PAPILLARE

Varieties.—The principal variations of the kidney are as follows:—

1. *In form.*—Disproportionate increase of one or other diameter, producing the long, globular, triangular, and discoid types.

2. *In size.*—Inequality; one being small, the other compensatingly large.

3. *In number.*—The organ may be single, then usually occupying its ordinary

position in one or other loin; or, still more rarely, it may be triple, in which case the additional gland is either lateral or median.

4. *In position.*—One or both kidneys may be above or below the normal level, in the latter and far more frequent case encroaching upon the iliac fossa, or even entering the true pelvis in front of or behind the rectum; or the displacement may be horizontal, the organ lying upon the vertebral column or even in the opposite loin.

5. By fusion of the two kidneys; the union involving the lower extremities only ('horseshoe kidney'), or the whole length of their inner borders.

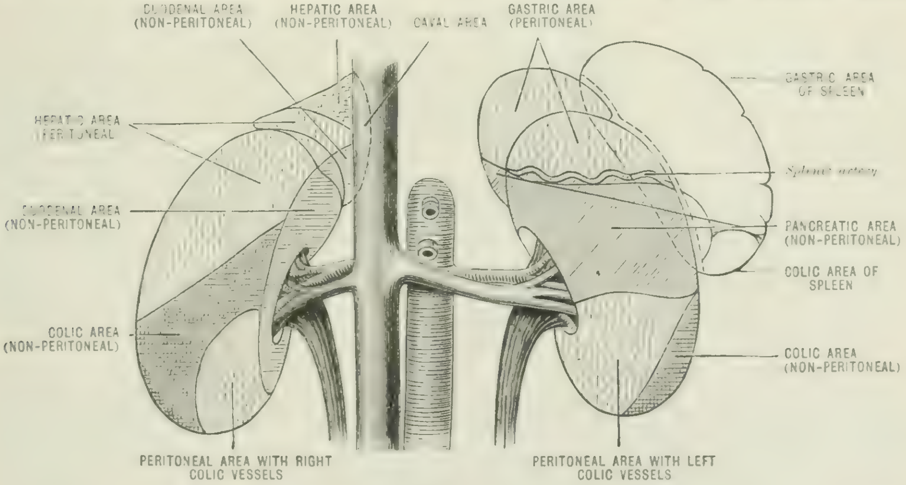
6. *In mobility.*—Undue mobility is usually, if not always, due to a laxity of that portion of the subperitoneal tissue which constitutes the fatty capsule; but a peritoneal meso-nephron is said to have been seen in extremely rare cases of movable kidney

THE SUPRARENAL BODIES

These structures do not form any part of the genito-urinary apparatus, but it is convenient to describe them in association with the glands by which they are supported.

The **suprarenal bodies** (fig. 615) are two solid viscera resting each upon the upper extremity of the corresponding kidney and the adjoining parts of its inner and anterior surfaces, and bound to it by subperitoneal connective tissue. They lie against the diaphragm opposite the eleventh rib, or tenth intercostal space, and are separated from each other by a space of about two inches and a half. The left is usually a little higher than the right, owing to the greater elevation of its kidney.

FIG. 615.—DIAGRAM SHOWING ANTERIOR RELATIONS OF KIDNEYS AND SUPRARENAL BODIES.


DUODENAL AREA (NON-PERITONEAL)
HEPATIC AREA (NON-PERITONEAL)
CAVAL AREA
GASTRIC AREA (PERITONEAL)
HEPATIC AREA PERITONEAL
GASTRIC AREA OF SPLEEN
Splenic artery
DUODENAL AREA (NON-PERITONEAL)
PANCREATIC AREA (NON-PERITONEAL)
COLIC AREA OF SPLEEN
COLIC AREA (NON-PERITONEAL)
COLIC AREA (NON-PERITONEAL)
PERITONEAL AREA WITH RIGHT COLIC VESSELS
PERITONEAL AREA WITH LEFT COLIC VESSELS

The organ varies widely in dimensions within physiological limits. Its average weight is about a drachm, its height an inch and a quarter (3 cm.), and its greatest breadth at the base an inch and three-quarters (4.5 cm.).

The *right* suprarenal body is pyramidal in form with the apex directed upwards and somewhat inwards. Its **anterior surface** is related above to a special impression upon the under and back part of the right lobe of the liver, between the layers of the coronary ligament; internally to the inferior vena cava which slightly overlaps it (Rolleston); and below is covered with peritoneum continuous with that of the kidney, except at its internal inferior angle where it is crossed by the hepatic flexure of the duodenum. It is rather firmly adherent to the liver, and the vessels of the two organs anastomose with each other at this point.

The *left* suprarenal body is a little larger than its fellow, somewhat crescentic in shape, and encroaches less upon the summit of the kidney than the right, and more upon the inner border, reaching even to the hilum. Its **anterior surface** is covered **above** by the peritoneum of the lesser sac, which separates it from the stomach; and below, near its internal inferior angle, it is crossed by the upper border of the pancreas and the splenic artery. **Externally** it is in contact with the upper extremity of the spleen, which passes a little behind it, and its inner border is separated from its aorta by the fibres of the diaphragm.

Accessory suprarenal bodies are often present in the neighbourhood of the principal organs.

Structure.—On section the organ is found to be covered by a thin fibrous capsule which sends trabecular processes between the cellular elements of its proper substance. The parenchyma consists of a peripheral portion or **cortex,** of yellowish colour, except in its deepest layer, which is darkly pigmented, and a central portion or **medulla,** soft and greyish, and tending to break down under decomposition in such a manner as to give the appearance of an irregular cavity (whence the name suprarenal 'capsule').

Vessels and nerves.—It is richly supplied both with vessels and nerves. Its **arteries** are derived from three sources—the aorta, the phrenic, and the renal—and pierce the organ in various places, but chiefly on the anterior surface along a furrow sometimes called the hilum. The **veins** terminate on the right side in the vena cava, and sometimes by means of small branches in the phrenic and renal trunks; on the left, in the left renal vein. The **lymphatics** pass to the renal glands, which, like the suprarenal bodies, themselves contain a good deal of pigment. The **nerves** form a rich and complex interlacement, and are derived chiefly from the solar and renal plexuses, but include filaments from the splanchnics, and according to some authors from the phrenic and vagus also. It is disproportionately large in early fœtal life, and has nearly reached its full growth at the time of birth.

THE RENAL DUCTS

The **excretory duct of the kidney** (figs. 607, 611, 616) is a musculo-mucous canal, expanded and irregularly branched above, narrow and of fairly uniform dimensions in the rest of its course. At its origin in the sinus renalis it appears in the form of a number of short tubes, usually eight or nine, called **calices,** each of which embraces the papillary extremity of a pyramid of Malpighi two or three lines above its apex, or occasionally two papillæ may be connected with a single calyx. The calices average about a third to half an inch (8 to 12 mm.) in length, and open directly or by means of intermediate tubes (**infundibula**) into two short passages, the **superior and inferior pelves,** which in turn combine after a longer or shorter course to form the **common pelvis.** The inferior and larger pelvis has a diameter of about two-fifths of an inch (10 mm.); the superior is about one-third less. Occasionally a third or **middle pelvis** is present.

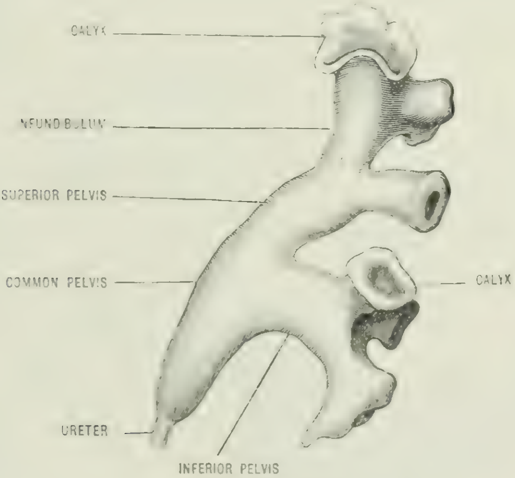
The **common pelvis** varies greatly in different subjects. It usually appears as a more or less funnel-shaped portion of the canal, wider above (about three-fifths of an inch—15 mm.), where it lies between the two lips of the hilum; narrow below, where it arches downwards and inwards to become continuous with the relatively uniform portion of the duct known as the **ureter proper.** In some cases, however, it can scarcely be said to exist as a dilatation. Under ordinary circumstances it is flattened from before backwards, its anterior and posterior walls being in contact, and its channel represented by a fissure. It is in relation behind with the posterior lip of the hilum, from which it is separated by more or less adipose tissue continuous with the fatty capsule, and occasionally by an irregular branch of the renal artery. The renal vein and artery lie in front, imbedded in fat, and anterior to these structures is situated the descending portion of the duodenum on the right side, and the pancreas on the left.

The **ureter** extends from the termination of the pelvis to the bladder, running in a kind of lymph-space between the laminæ of the subperitoneal tissue. It is a tube of about a fifth of an inch (5 mm.) in diameter when distended, and is fairly uniform in size, except about two inches below the kidney, where a slight constriction is usually found (Bruce Clark). Its length is variously stated, but the average in the male adult may be taken as about twelve inches (30 cm.), the right being usually a little the shorter. The excessive estimates sometimes given depend upon the untrustworthy indications afforded by admeasurement after the removal of the structure from the body.

Course and relations.—The tubes lie about three inches apart at their commencement, but this distance gradually lessens to about two inches as they descend towards the sacro-iliac joint. In the true pelvis they at first diverge, but finally on nearing the base of the bladder run forwards and inwards to pierce the wall of the viscus, and at their termination are separated by a distance of about an inch (25 mm.). The course of each tube may be conveniently divided into three stages, abdominal, pelvic, and vesical. The **abdominal portion,** running downwards and slightly inwards, is in relation, *posteriorly*, with the psoas and its fascia, and the genito-crural nerve, and with the common iliac artery near its bifurcation. *Anteriorly*, it is covered by peritoneum and intestines, and is crossed by the colic and spermatic vessels. *Internally*, it is opposed on the right side to the inferior vena cava, on the left to the aorta; the vein being almost in contact with the right ureter, while the artery is separated from the left tube by an interval that gradually diminishes from one inch above to half an inch opposite the bifurcation of the vessel. In the female the utero-ovarian veins lie on its inner side.

The **pelvic portion** runs in front of the sacro-iliac synchondrosis, then upon the obturator internus and its fascia behind and below the psoas, and on the outer side of the pelvic coils of intestine (sigmoid colon on left side, small intestine on right), finally leaving the pelvic wall to join the bladder. In this position, in the *male* it is crossed superiorly and internally by the vas deferens, and lies under cover of the free extremity of the vesicula seminalis, separated from its fellow by a distance of an inch and a half (37 mm.). In the *female* it runs parallel with, and four to six lines (8 to 12 mm.) from, the cervix uteri, behind the uterine artery, through the uterine plexus of veins, and beneath the root of the broad ligament; finally crossing the upper third of the vagina to reach the vesico-vaginal interspace and pierce the bladder opposite the middle of the vagina. A calculus in the lower end of the tube might be detected by a vaginal examination.

FIG. 616.—UPPER PORTION OF DUCT. (After Henle.)



The **vesical portion,** about half an inch (12 mm.) in length, runs obliquely downwards and inwards through the coats of the bladder, and opens on to the mucous surface at a distance of about three-quarters of an inch to an inch (18 to 25 mm.) from its fellow, and from the internal urinary meatus.

Structure.—The wall of the ureter is about a twenty-fifth of an inch (1 mm.) in thickness, and consists of a mucous membrane, a muscular coat, and an external connective tissue investment. The **mucous membrane** is longitudinally plicated, and is lined with a multiple layer of transitional epithelium, continuous with that of the papillæ above, and with that of the bladder below. Mucous follicles of simple form have been found in the upper part of the canal. The **muscularis** is about one-fiftieth of an inch (.5 mm.) in thickness, and consists of two layers, an external composed of annular fibres, an internal of fibres longitudinally disposed. After the tube has entered the bladder the circular fibres appear as a kind of sphincter around its vesical orifice; while the longitudinal fibres spread out to form with those of the opposite side a triangular expanse with its apex at the internal urinary meatus and its base corresponding to a line drawn between the two ureteric orifices, the upper (interureteric) and lower (uretero-meatal) fibres forming strong bands which bound the triangle.

Vessels and nerves.—The **arteries** of the ureter come from the renal, spermatic or utero-ovarian, internal iliac, and vesical; the **veins** terminate in the corresponding trunks; and the **lymphatics** pass to the renal, lumbar, and pelvic glands and into the receptaculum chyli. The **nerves** are supplied by the spermatic, renal, and hypogastric plexuses.

Varieties.—The most important variation consists in the partial or complete duplication of the tube owing to the late union or to the non-union of the superior and inferior infundibula or pelves. In rare cases three pelves may in like manner remain separate in part or in the whole of their course to the bladder.

THE BLADDER

The **urinary bladder** is a receptacle, of which the form, size, and position vary with the amount of its contents. The adult organ in its empty or moderately filled condition lies entirely below the level of the oblique plane of the pelvic inlet; but when considerably distended it rises into the abdomen and shows itself beneath the parietes as a characteristic mesial projection above the symphysis, a projection which in certain cases may extend nearly to the level of the umbilicus. It is invested over its whole extent by recto-vesical fascia, and is partially covered above and behind by peritoneum (fig. 617).

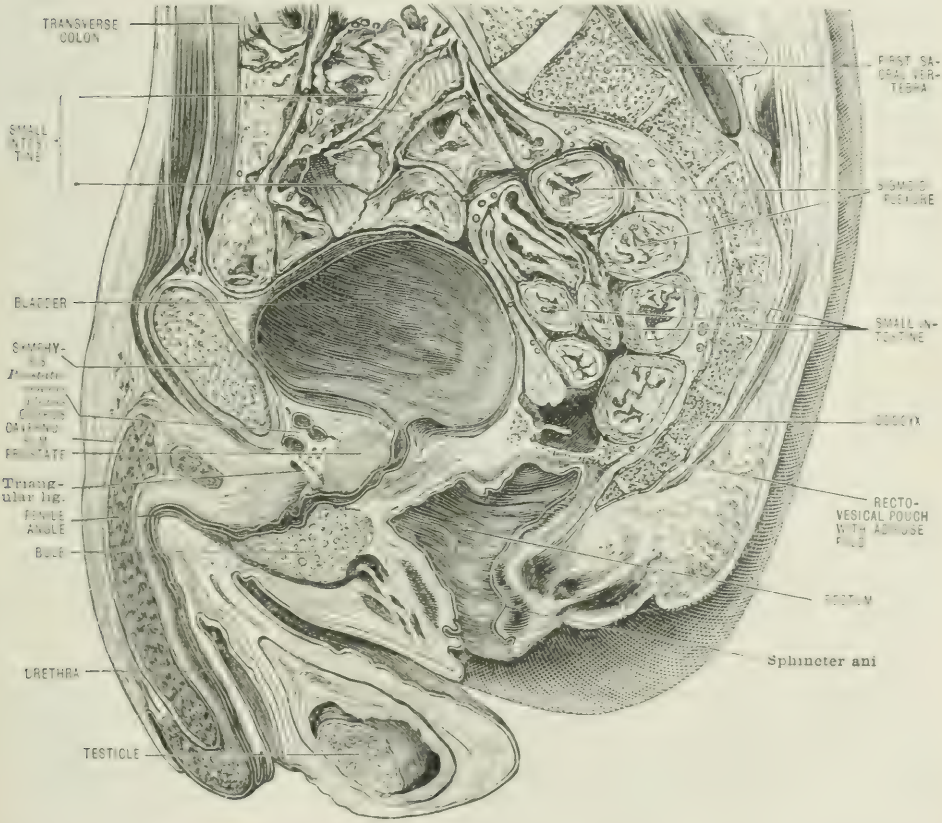
Form.—When fully distended it assumes in the male an ovoid shape with its longest diameter directed downwards and backwards, but in women the transverse diameter is commonly the greatest, owing to the different shape of the pelvic cavity. In the child it is somewhat pear-shaped, the stalk being represented by the urachus.

The form of the empty bladder is still doubtful, as the appearances in the dead subject do not necessarily coincide with the condition existing during life. In mesial sagittal section it usually appears somewhat cup-shaped, its upper wall presenting a rounded or pyramidal hollow to the intestines, while its cavity is represented by a T or Y-shaped fissure (as in plate 1 of Symington's 'Anatomy of the Child'). It is probable that this 'diastolic' form, as it has been termed, is not altogether the normal result of a relaxation preliminary to refilling; but is partly due to the loss of vital elasticity of the muscular wall, and that the healthy living bladder maintains a rounded or ovoid form even when empty.

The three terms, 'apex' or 'superior fundus,' 'inferior fundus,' and 'neck,' are commonly applied to parts of the bladder: the first to the point of attachment of the superior ligament or urachus (a relic of the tube of communication between the bladder and allantois) which connects it with the umbilicus; the second to the lower part of the organ, and the third to the point at which the vesical cavity becomes continuous with the urethra; but the expressions are all more or less objectionable, and serve no useful purpose. Under ordinary distension the so-called 'apex' is as much rounded as the rest of the viscus; the anatomical limits of the 'inferior fundus' are still undefined; and the only 'neck' that can be assigned to the bladder is represented by the prostate and prostatic urethra.

Relations.—The bladder when moderately filled may be said to present for description five aspects or surfaces: antero-inferior or pubic, posterior or rectal, superior or intestinal, and two lateral or obturator surfaces. The anterior, posterior, and lateral surfaces meet above at the urachus, and converge below towards the base of the prostate—the posterior wall sometimes approaching the urethral orifice almost in a vertical direction, as in Braune's section (plate 2), or curving first downwards, and then forwards, as in fig. 617; and in old subjects this curve may be so exaggerated that a kind of pouch is formed behind the internal meatus. The **antero-inferior surface** looks downwards and forwards towards the symphysis. It is uncovered by peritoneum, but has a strong investment of recto-vesical fascia, and is separated from the pubic bones and anterior attachments of the obturatores interni and levatores ani by a space known as the **cavum Retzii**, which contains a variable quantity of loose fat continuous with the pelvic and abdominal subperitoneal tissue. Each **lateral surface** is covered by peritoneum down to the level of a line extending from the urachus backwards to a point below the summit of the vesicula seminales, about an inch above the base of the prostate. Below this level it is separated from the levatores ani by subperitoneal tissue, which usually bears much fat in its meshes and ensheaths the vesical vessels and nerves; and it is crossed by the vas deferens, and at the point of peritoneal reflexion by the obliterated hypogastric artery. The ureter pierces the junction of the posterior and lateral surfaces about an inch and a half above the prostate, the vas running between it and the vesical wall. External to these structures the lateral wall is in relation to the levator ani and the obturator internus. The **posterior surface** may be divided into two portions, an upper covered by the peritoneum of the recto-vesical or utero-

FIG. 617.—MEDIAN SAGITTAL SECTION OF THE MALE PELVIS.
(From a preparation in the Museum of St. Thomas's Hospital.)


TRANSVERSE COLON
SMALL INTESTINE
BLADDER
SYMPHYSIS
CORPUS CAVERNOSUM
PROSTATE
Triangular lig.
PENILE ANGLE
BULB
URETHRA
TESTICLE
FIRST SACRAL VERTEBRA
SIGMOID FLEXURE
SMALL INTESTINE
COCCYX
RECTO-VESICAL POUCH WITH ADIPOSE FOLD
RECTUM
Sphincter ani

vesical pouch, a lower in direct contact with the anterior wall of the rectum, and the lower part of the vasa deferentia and vesiculæ seminales. The distance of the recto-vesical *cul-de-sac* of peritoneum from the prostate is very variable, but usually ranges between half an inch and one inch (12 to 25 mm.), and may be increased to two inches (5 cm.) by distension of the bladder. It is, however, very small in the child. The ureters where they lie at the outer limits of this surface are near to though not in contact with the rectum, and a calculus in the lower end of the urinary tube might be felt by an exploration from within the bowel. In the lower portion of the posterior wall in the male is a **triangular space**, the sides of which are formed by the diverging vasa deferentia, the base by the line of reflexion of the recto-vesical pouch of peritoneum, and the apex by the meeting of the ejaculatory ducts at the summit of the prostate. It was formerly selected as the position for the introduction of a trocar through the rectum into the bladder in cases of retention of urine. *In the female* the posterior surface is adherent below to the cervix uteri and upper part of the anterior wall of the vagina, but is separated above from the body of the uterus by a shallow utero-vesical pouch of peritoneum.

The **superior surface** is entirely covered with peritoneum. It looks almost directly upwards into the abdominal cavity, and lies in contact with the small intestines, and sometimes with a portion of the sigmoid colon behind these.

Effects of distension.—When the bladder becomes excessively full it rises above the level of the symphysis, and in certain chronic conditions of retention may even mount as high as the umbilicus. During the process of distension the anterior wall carries upwards the peritoneal fold reflected on to its upper surface. This elevation is, however, variable and limited in extent; at its maximum it seldom exceeds two inches (5 cm.), and in some instances fails even to pass the upper border of the symphysis, hence there is some danger in tapping the bladder above the pubes, unless the part is exposed by a careful dissection. In recent years Garson and Petersen have demonstrated that the introduction into the rectum of a bag of suitable dimensions filled with air or water pushes forward the expanded viscus and may still further increase the available space for surgical operation, but it does not ensure the elevation of the peritoneal fold above the symphysis.

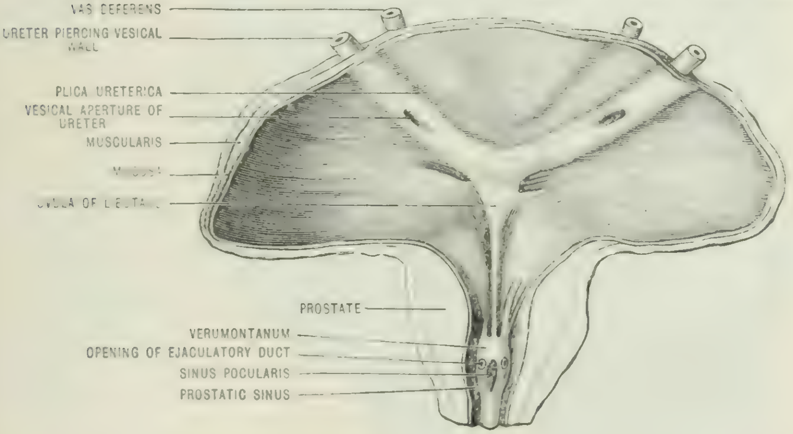
The relation of the **internal urinary meatus** to the pelvic wall has become a subject of interest since the revival of suprapubic operations upon the bladder. As a rule it lies at some point opposite the upper half of the symphysis, but in great distension of the viscus (see Rüdinger, plate 3) it may descend to a lower level. On the other hand, in young children it usually reaches the level of the upper border of the symphysis, and in old persons with prostatic disease it may rise even above this point. In the male adult it lies from three-quarters of an inch to an inch (2 cm. to 2.5 cm.) behind the symphysis, and about two or two and a half inches (5 cm.) above the perinæum.

Structure.—The bladder wall is composed mainly of unstriped muscular fibre, invested externally by a layer of recto-vesical fascia and a partial covering of peritoneum, and lined with mucous membrane and submucous tissue. Its thickness varies greatly in different subjects and in the same subject under different conditions of distension. It is estimated at about an eighth of an inch when moderately stretched, but may reach half an inch or even more when completely contracted. It is somewhat thicker at the trigone.

The arrangement of the **peritoneum** over the superior, lateral, and posterior walls has been described, and it only remains to mention that its reflexions over the urachus above, and from the sides and back of the bladder below, form the superior, lateral, and posterior **false ligaments**. The **recto-vesical fascia** is a well-developed layer of tissue over the lower part of the viscus, but is greatly attenuated above. It is continuous below with the capsule of the prostate, and passes on to the pubic bones in front of the latter organ in the form of a double fold called the **pubo-prostatic** or **anterior true ligaments**, and upon the levator ani at the sides, where its reflexions are termed the **lateral true ligaments**, while the urachus above represents a **superior ligament**. These traditional names, however, are misleading and have no practical value. The **muscular coat** is composed of unstriped fibres, which may be divided roughly into three layers, an outer principally longitudinal, a middle chiefly transverse, and an inner plexiform, but tending towards the vertical direction. The fibres of the *outer* layer are most distinctly longitudinal on the anterior and posterior surfaces, and extend above along the urachus, but they run obliquely over the sides of the bladder, decussating with each other in a complex manner; and near the urethral end of the viscus two strong bundles of the anterior longitudinal fibres run one on each side of the middle line in front of the anterior wall of the prostate and beneath the pubo-prostatic ligament, to become attached to the back of the pubic bones on each side of the symphysis (**vesico-pubic muscle**). The lower fibres of the middle layer form a kind of annular sphincter near the urethral orifice (**sphincter vesicæ internus**), the fibres of which are continuous with the upper sphincteric fibres of the prostate, and at the trigone are reinforced by the expansion of the longitudinal ureteric fibres named on page 1016. The *inner layer* appears as a set of well-defined bands running in a longitudinal direction and communicating with each other by means of oblique fasciculi. These bands, when hypertrophied, appear as distinct ridges beneath the mucous membrane, and their interspaces may be seen as depressions which occasionally develop into diverticula. At the trigone, the inner layer is strengthened by the radiation of the ureteric fibres.

The rather coarse meshwork formed by the decussating muscular bundles is apt to present weak points through which the mucous membrane may protrude as **diverticular sacculations**, sometimes of considerable size and capable of lodging calculous concretions. On the other hand, when the muscular tissue becomes hypertrophied from excessive use, it often forms strong ridge-like projections which may give rise to deceptive impressions during exploration of the cavity with the sound.

Fig. 618.—The Posterior Wall of the Bladder. (After Henle.)



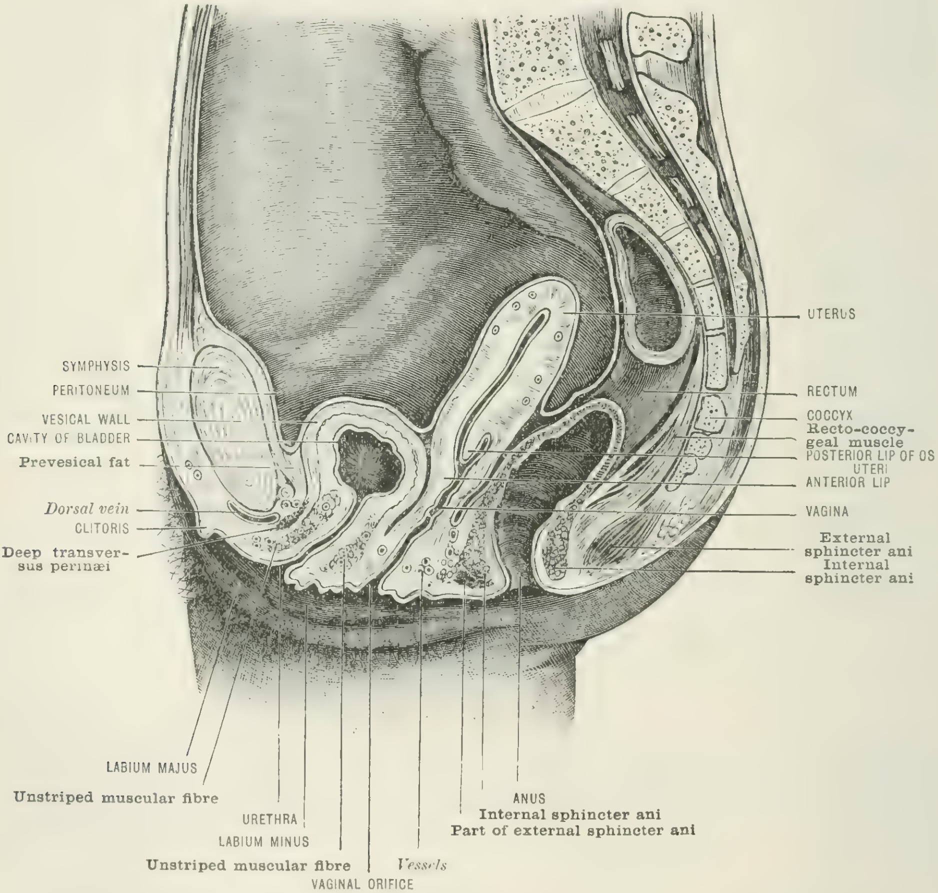
The **submucous coat** consists of a highly elastic connective tissue devoid of muscular fibres.

The **mucous membrane** is smooth, soft, and rose-coloured during life. In the empty bladder it is thrown into irregular folds, which become effaced by distension. It is modified posteriorly over a triangular area called the **Trigone of Lieutaud** (fig. 618), the three angles of which lie at the internal meatus and the two ureteric orifices, and are at a distance from each other of three-quarters of an inch to an inch (18 to 25 mm.). This region, which lies opposite to the 'second portion' of the rectum, is free from the plication that appears in the rest of the mucous membrane during contraction of the cavity, and is bounded by a transverse elevation between the ureters, called the **plica ureterica**, and presents a longitudinal mesial ridge, the **uvula of Lieutaud**, near the urethral orifice. It is smaller and less distinct in the female. The *internal urinary meatus* usually lies at the most dependent part of the bladder, but in morbid conditions of the prostate the borders of the aperture may be considerably elevated above the adjacent vesical zone.

The **female bladder** (fig. 619) presents no peculiarities of importance, except that its frontal diameter is usually increased at the expense of the sagittal diameter, partly in consequence of the greater width of the pelvis, and partly owing to the presence of the vagina and uterus, which encroach upon the space in the middle line. Lateral asymmetry is very common. Furthermore, the symphysis being of less depth than in the male, the urinary orifice lies nearer its lower border.

In the **infant** the bladder is said to be an abdominal organ, but this is not strictly accurate. The relatively small pelvic cavity at this period of life is occupied mainly by the rectum, and there is little room for the bladder, which hence rises into the abdomen even in moderate degrees of distension; but, as pointed out by Symington, if a line be drawn from the sacral promontory to the top of the symphysis, fully one-half of the bladder will be found to lie below it, and hence within the pelvis. The internal meatus, however, is behind the upper margin of the symphysis, and the whole organ is hence above the horizontal level of the pubic crests. This relation gradually changes from the period at which independent locomotion begins, till, by the age of six, when the pelvic wall has grown up around the viscus, the position does not differ materially from that in the adult. It should also be noted that the recto-vesical fold of peritoneum extends in infancy nearly as low as the base of the prostate.

FIG. 619.—SECTION OF THE FEMALE PELVIS. (After Henle.)


UTERUS
SYMPHYSIS
PERITONEUM
VESICAL WALL
CAVITY OF BLADDER
Prevesical fat
Dorsal vein
CLITORIS
Deep transversus perinæi
RECTUM
COCCYX
Recto-coccygeal muscle
POSTERIOR LIP OF OS UTERI
ANTERIOR LIP
VAGINA
External sphincter ani
Internal sphincter ani
LABIUM MAJUS
Unstriped muscular fibre
URETHRA
LABIUM MINUS
Unstriped muscular fibre
Vessels
VAGINAL ORIFICE
ANUS
Internal sphincter ani
Part of external sphincter ani

Vessels.—The **arteries** of the bladder are derived from the internal iliac and internal pudic, and in the female some twigs are also given off by the uterine and vaginal arteries. The **veins** terminate in the internal iliac trunk. They form plexuses which are especially large about the parts adjacent to the prostate, and communicate in the male with all the veins in the neighbourhood. *Lymphatics* appear as a submucous plexus which is most developed in the neighbourhood of the internal meatus. They accompany the veins and terminate in the internal iliac glands.

Nerves.—The nerves are derived, partly from the sympathetic system through the hypogastric plexuses, partly from the cerebro-spinal system through the third and fourth sacral nerves. The former supply the mucosa, the latter the muscularis.

THE MALE REPRODUCTIVE ORGANS

The **reproductive organs of the male** consist of (1) two testicles or seminal glands, with their excretory tubes; (2) a musculo-glandular organ, the prostate, which provides a material for the dilution of the semen, and by its sphincteric contraction aids in the ejaculation of the spermatic fluid, and at the same time intercepts its retrograde passage into the bladder; (3) an organ of copulation, the penis; and (4) a canal, the urethra, which pierces the prostate and penis, and serves for the transit of both the generative and urinary secretions.

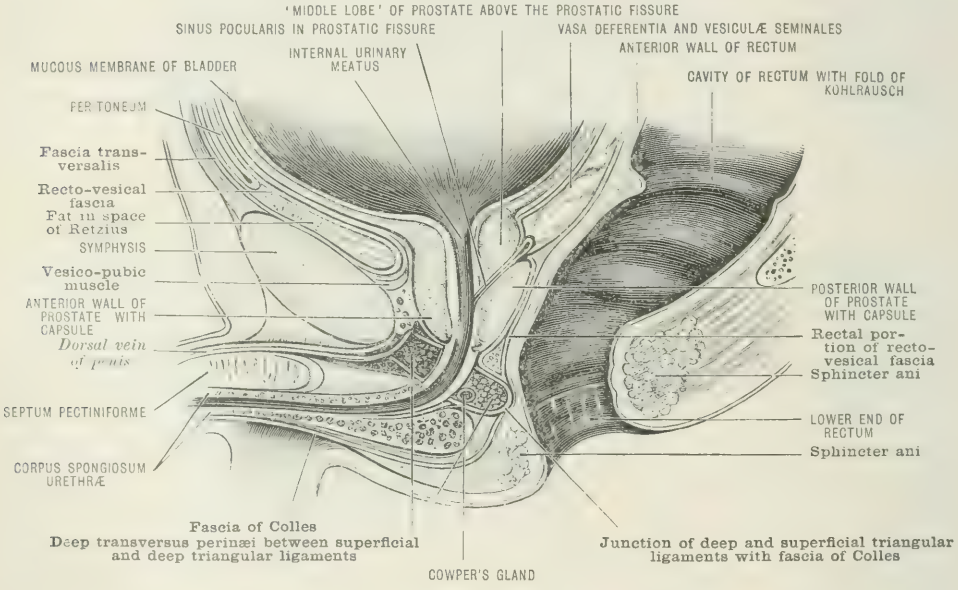
THE PROSTATE

The **prostate** is a firm elastic and contractile organ, lying between the bladder and the penis, and perforated by the urethra (figs. 620, 624, and 649). It is roughly comparable to a horse-chestnut in form and dimensions; its broader extremity or base lies uppermost and blends with the vesical sphincter, while its apex rests against the superior triangular ligament. Its long axis is vertical (in the erect posture), or inclines slightly forwards below (fig. 617), and is nearly an inch and a quarter (3 cm.) in length. Its transverse diameter, greatest near the base, measures about an inch and a half, and its antero-posterior diameter about an inch. Its average weight is about six drachms, nearly the same as that of the testicle, and it may be noted that the active evolution of the two organs begins at the same period, at puberty, and that the structural and functional development of the one is intimately associated with that of the other during the period of sexual vigor. It offers for description a base, an apex, and anterior, lateral, and posterior walls. The **base** is connected with the musculature of the bladder, receiving the attachment of the longitudinal fibres and surrounding the sphincteric portion of the circular layer at the urethral orifice. It usually lies a little above the level of the middle of the symphysis. The **apex**, resting against the superior or deep triangular ligament, is from one-half to three-fourths of an inch (12 to 18 mm.) behind and a little below the subpubic angle, and on rectal exploration will be found about an inch and a quarter above the margin of the anus. The **anterior wall** is rounded, and is covered by the prostatic plexus of veins and the vesico-pubic muscle and pubo-prostatic ligaments (page 1018). The **lateral walls** are in contact with the inner borders of the two levatores ani muscles and the marginal portion of the venous plexus, and project above and behind in the form of ill-defined **lateral lobes,** which may be looked upon as the persistent indication of its development in two halves. The **posterior wall** is flattened and is opposed to the rectum, from which it is separated by some connective tissue and unstriped muscular fibres continuous with the subperitoneal tissue and pelvic fascia. Near its upper border is a transverse median cleft, the **prostatic fissure** (fig. 624), which extends deeply inwards and forwards towards the middle of the prostatic urethra, transmitting the common ejaculatory ducts and the sinus pocularis, and in section (fig 620) appearing as the posterior and inferior boundary of a portion of the substance of the organ, the so-called **'middle lobe.'**

An irregular artery, usually derived from the internal iliac trunk, is sometimes found running by the side of the prostate to reach the dorsum of the penis, and may be the source of dangerous haemorrhage in lateral lithotomy. It replaces one or more of the terminal branches of the internal pudic.

Structure and function.—The prostate is invested by a fibro-muscular capsule, derived from the recto-vesical segment of the pelvic fascia, unstriped muscle existing in largest proportion over its rectal aspect, between the opposed borders of the levatores ani. The organ itself is composed of muscular and glandular tissue. The muscular element, comprising both striped and unstriped fibres, represents about one-half of the entire mass. The unstriped fibres embrace the vesical sphincter above, forming with this a ring of great firmness and strength above the urethral orifices of the ejaculatory ducts, and discharging in all probability the function of intercepting the backward flow of the semen and prostatic fluid into the bladder during sexual congress; below this point, the muscle is intermingled with gland tissue and striated fibres. The striped fibres lie chiefly in the anterior wall of the prostate, but completely encircle the apex of the organ, and are there probably connected with the deep transversus perinæi. The muscular fibres of both kinds below the ejaculatory ducts undoubtedly initiate the forward propulsion of the mingled prostatic and seminal secretions; the ejaculation being further aided by the contraction of the deep transversus perinæi, and bulbo-cavernosi.

FIG. 620.—SEMI-DIAGRAMMATIC SECTION OF THE MALE PELVIS.


'MIDDLE LOBE' OF PROSTATE ABOVE THE PROSTATIC FISSURE
SINUS POCULARIS IN PROSTATIC FISSURE
VASA DEFERENTIA AND VESICULÆ SEMINALES
ANTERIOR WALL OF RECTUM
INTERNAL URINARY MEATUS
MUCOUS MEMBRANE OF BLADDER
CAVITY OF RECTUM WITH FOLD OF KOHLRAUSCH
PERITONEUM
Fascia transversalis
Recto-vesical fascia
Fat in space of Retzius
SYMPHYSIS
Vesico-pubic muscle
ANTERIOR WALL OF PROSTATE WITH CAPSULE
Dorsal vein of penis
SEPTUM PECTINIFORME
CORPUS SPONGIOSUM URETHRÆ
POSTERIOR WALL OF PROSTATE WITH CAPSULE
Rectal portion of recto-vesical fascia
Sphincter ani
LOWER END OF RECTUM
Sphincter ani
Fascia of Colles
Deep transversus perinæi between superficial and deep triangular ligaments
Junction of deep and superficial triangular ligaments with fascia of Colles
COWPER'S GLAND

The glands are of the branched tubular type, and lie chiefly in the posterior and lateral parts of the organ, their ducts opening into the urethral recesses (**prostatic sinuses**) by the sides of the verumontanum. They secrete a mucus, the principal use of which is to dilute and give bulk to the semen, and they are sometimes the seat of pathological concretions. In addition to the true glands are seen a number of simple follicles in the anterior wall of the prostatic urethra, probably of the same nature as the rest of the urethral follicles. The prostatic urethra will be described hereafter (page 1037).

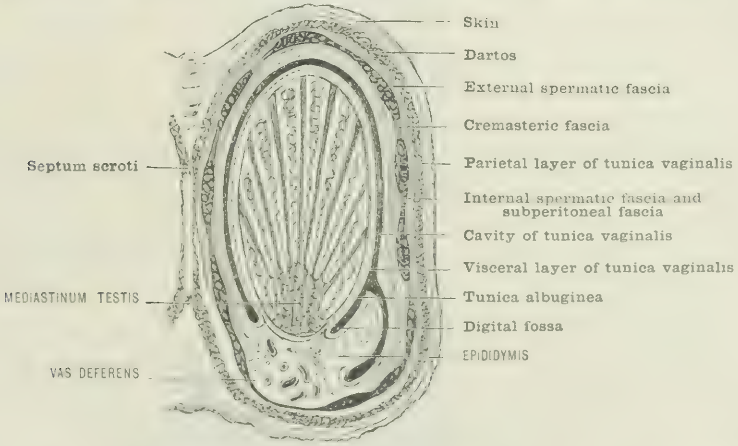
The organ is essentially generative, but serves also to reinforce the vesical sphincter, although its absence in the female and its imperfect development in children and eunuchs appear to entail no defect in the control of the bladder. The muscular fibres are, however, to some extent represented in the female (page 1042).

Vessels and Nerves.—The **arteries** of the prostate arise from the adjacent vesical and hæmorrhoidal vessels. The prostatic **veins** receive the dorsal vein of the penis, and after forming a plexus (**plexus of Santorini**) investing the anterior and a portion of the lateral surfaces, terminate in the adjacent vesical veins. The **lymphatics** end in the pelvic glands, and a small gland may sometimes be found on each side near the base of the organ. The **nerves** are derived from the hypogastric plexus.

THE TESTICLES AND THEIR APPENDAGES AND COVERINGS

The two testicles lie in a common pouch of integument called the **scrotum**, and each organ is invested in addition by a series of coverings which join in the middle line to form a **septum scroti.** There are three principal layers: an outer (the dartos) of unstriped muscular fibre, a middle (the cremasteric) containing striped muscular fibre, and an inner serous (the tunica vaginalis), separated from each other by layers of connective tissue. The coverings (fig. 621), named from without inwards, are (1) the dartos; (2) the external spermatic fascia; (3) the cremasteric or middle spermatic fascia; (4) the internal spermatic fascia; (5) subperitoneal fascia; and (6) the tunica vaginalis.

FIG. 621.—HORIZONTAL SECTION OF THE SCROTUM AND TESTICLE. (Diagrammatic.)


Skin
Dartos
External spermatic fascia
Cremasteric fascia
Septum scroti
Parietal layer of tunica vaginalis
Internal spermatic fascia and subperitoneal fascia
Cavity of tunica vaginalis
Visceral layer of tunica vaginalis
MEDIASTINUM TESTIS
Tunica albuginea
Digital fossa
EPIDIDYMIS
VAS DEFERENS

THE SCROTUM.—The **scrotal integument** is more or less pigmented, and covered in the adult with coarse, scattered hairs, and provided with strongly developed sebaceous and sudoriparous glands. It presents in the middle line a longitudinal impression, the **raphé**, from which start on either side a multitude of transverse wrinkles, effaceable by distension.

(1) The **dartos** is a thin reddish layer composed of elastic tissue freely intermingled with unstriped muscular fibres. It is adherent to the deep surface of the skin, but passes inward septally between the two testicles, forming a separate sac for each, and is prolonged over the penis and perinæum. Its fibres assume various directions, but for the most part run longitudinally at right angles to the scrotal wrinkles, of which they are the cause. They are always moderately contracted in health, and contract still more under the influence of cold and of mental emotion, but are not affected by electricity. They become relaxed in conditions of general enfeeblement. According to Barrois, the dartos is divided into two layers, the more superficial being common to both testicles, while the deeper and stronger forms a separate investment for each testicle, and assists in the formation of the septum scroti.

(2) The **external spermatic** or '**intercolumnar**' **fascia** consists of a fatless, laminated connective tissue, within and closely adherent to the dartos, blending at

the external inguinal opening with the strong fibrous bands crossing the columns of the ring, and prolonged, like the dartos, over the penis and perinæum. It is continuous behind with the deep layer of the superficial perinæal fascia, and above with the superficial fascia over the symphysis.

(3) The **cremasteric** or **middle spermatic fascia** is a well-defined fibro-muscular expansion covering the cord and testicle. It consists of a strong double lamina of areolar and elastic tissue enclosing and connecting longitudinal bundles of striped muscle, the fibres of which may be traced above to the external inguinal ring, where they are divided into two principal sets: an inner (often absent), attached to the pubic spine, and an outer derived from the lower border of the internal oblique, and arising from Poupart's ligament opposite the inguinal ring. Below, the tunic blends with the dartos opposite the lower extremity of the testicle. The cremaster contracts during convulsive expiratory actions of the abdominal muscles and under emotional influences.

(4) The **internal spermatic** or '**infundibuliform**' **fascia** is a delicate connective tissue derived from the fascia transversalis.

(5) The subperitoneal fascia beneath the last, and more or less blended with it, is a laminated prolongation of the subperitoneal tissue closely investing the elements of the cord and testicle. It contains elastic fibres, adipose tissue, and unstriped muscular elements, and is the seat of the fatty tumors of the cord which occasionally simulate inguinal hernia. The muscular fibres form a longitudinally directed layer on the deep aspect of the connective-tissue fibres, and are called 'middle cremaster' by Klein and Barrois to distinguish them from the 'external cremaster' of striped fibres and the 'internal cremaster' described in connection with the cord.

(6) The **tunica vaginalis,** a serous investment of the testicle, is described below.

Vessels and Nerves.—The skin and dartos are supplied by branches of the external pudic and superficial perinæal **arteries,** while the cremaster, the internal spermatic fascia, the subperitoneal fascia, and the visceral layer of the tunica vaginalis receive a special branch from the deep epigastric; the corresponding **veins** communicate with the pudic, the long saphenous, and the dorsal vein of the penis. The **lymphatics** terminate in the innermost set of the inguinal glands (the lymphatics of the testicle itself passing to the lumbar glands). The **nerves** are derived from the genito-crural and superficial perinæal.

THE TESTICLES.—The testicles (fig. 622), two in number, are suspended from the inguinal region by the spermatic cords. The left is supposed to hang somewhat lower than the right in the majority of persons. Each gland consists of two portions, the testicle proper and the epididymis. Its weight as a whole averages between five and six drachms, rarely attaining the maximum of an ounce; it is about an inch and a half (4 cm.) in length, an inch and a quarter (3 cm.) in depth (from the anterior to the posterior border), and somewhat less than an inch (22 mm.) in thickness. It is so suspended in the scrotum that its upper extremity inclines a little more forward than the lower, and its inner surface is turned slightly forwards as well as inwards.

The **Testicle proper** is shaped somewhat like a kidney bean; it is elongated from above downwards, and flattened from side to side. Its surface is smooth and white, and is covered by the visceral layer of the tunica vaginalis, except where it is in contact with the epididymis.

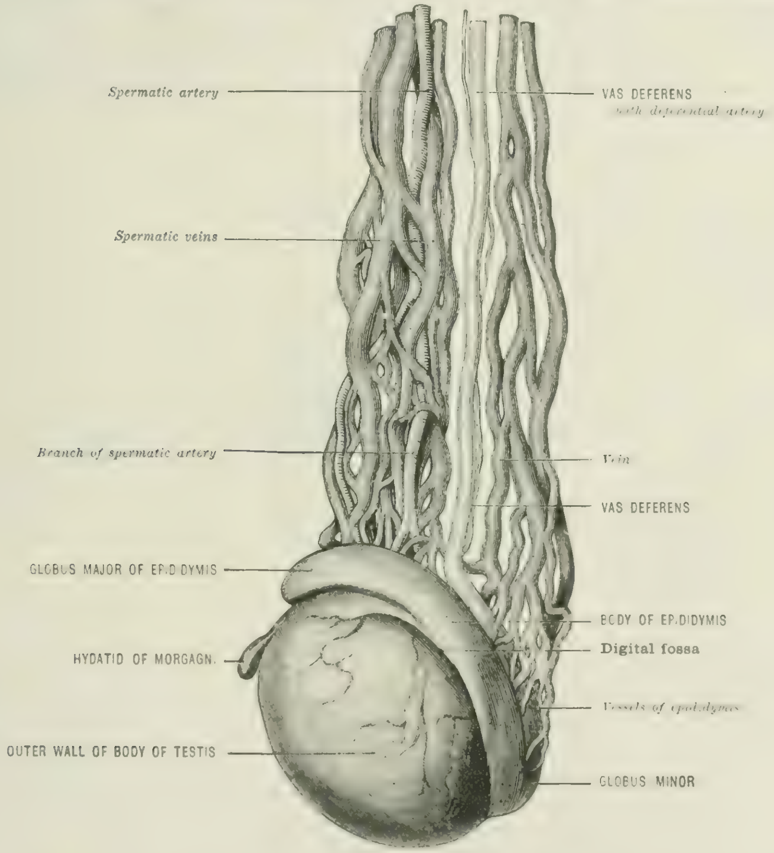
The **Epididymis** is adherent to the posterior and inferior part of the testicle proper and inclines slightly to the outer side. It is enlarged above into a head or **globus major,** and below into a tail or **globus minor,** the intermediate portion being called the **body.**

The **Tunica Vaginalis** is a serous sac of peritoneal origin, which bears to the testicle a relation similar to that of the serous pericardium to the heart. It consists of parietal and visceral layers.

The *visceral layer* is intimately adherent to the testicle proper, and to the globus major and outer part of the body of the epididymis, and is prolonged upwards for about half an inch upon the spermatic cord. On the outer side and above, it extends into a deep depression, the **digital fossa,** between the testicle and epididymis; but it leaves uncovered nearly the whole of the globus minor and the internal and posterior surfaces of the body of the epididymis, and it is in these situations that an important vascular communication is established between the gland and its coverings.

The *parietal layer*, continuous with the visceral layer at the posterior and inferior parts of the testicle and at the point of reflexion from the spermatic cord, becomes loosely attached to the internal spermatic fascia by means of a prolongation of the abdominal subperitoneal tissue. It contains a number of unstriped muscular fibres running longitudinally and continuous with the internal cremaster. Under normal conditions, the two serous layers are in contact, the serous fluid being secreted only in sufficient quantity to moisten the opposed surfaces. An undue increase of the amount constitutes the disease known as vaginal hydrocele.

FIG. 622.—THE LEFT TESTICLE WITH VESSELS AND DUCT. (After Sappey.)


Spermatic artery
VAS DEFERENS
with deferential artery
Spermatic veins
Branch of spermatic artery
Vein
VAS DEFERENS
GLOBUS MAJOR OF EPIDIDYMIS
BODY OF EPIDIDYMIS
Digital fossa
HYDATID OF MORGAGNI
Vessels of epididymis
OUTER WALL OF BODY OF TESTIS
GLOBUS MINOR

The testicle is occasionally so rotated upon its long axis that the epididymis becomes turned towards the front of the scrotum. In this case, were a hydrocele to occur, the sac would project posteriorly. The side to which a detached testicle belongs may be distinguished by remembering that the epididymis is attached behind, and that the digital fossa of the tunica vaginalis lies on the outer side.

In order to understand the relations of the organ to adjacent structures it is necessary to learn something of the mechanism of its descent. The testicle is at first an abdominal organ lying below the kidney and invested by a layer of peritoneum (**mesorchium**) which is firmly adherent to its surface in front and at the sides. It is, moreover, connected by bundles of unstriped muscular fibres, the **gubernaculum testis,** with the pillars of the external inguinal ring and with the dartos at the bottom of the scrotum. It begins to descend in the early part of the third month of fœtal life, reaching the internal inguinal ring in the sixth month. It then passes obliquely through the structures of the abdominal wall, preceded by a pouch of peritoneum and pushing before it, in succession, the subperitoneal tissue, an infundibuliform prolongation of the fascia transversalis, a few fibers of the internal oblique (which form part of the external cremaster), and the intercolumnar fascia, which braces together the pillars of the external inguinal ring. At the eighth month it appears at the external ring, and reaches the bottom of the scrotum shortly before birth.

The cause of this migration is still uncertain. The theory usually adopted is that the descent is effected partly by the development of the pelvic and lumbar regions which grow upwards, and in a manner leave the testicle, fixed by the gubernaculum, behind. This accounts for the change of position to the level of the inguinal canal, but the mechanism of the further descent into the scrotum is unknown. It was formerly attributed to the progressive shortening of the gubernaculum, and in accordance with this view, the unstriped muscular fibres connecting the bottom of the gland with the scrotum are regarded as the remains of the central and principal gubernacular band, while the lateral bands, ceasing to act after the testicle has reached the external ring, are drawn down into the scrotum and appear as scattered groups of fibres, the **internal cremaster** of Henle, lying around the elements of the spermatic cord (fig. 626).

In certain individuals, the descent of one or both testicles into the scrotum is intercepted, and cryptorchism results. This condition is normal in certain animals (elephants, cetacea, etc.), but in man is always associated with defective evolution of the organ, and consequent suppression of function.

The peritoneal sac carried with the testicle is at first continuous with the abdominal peritoneum. In most cases the tube of communication gradually narrows, and at length, within a few days after birth, becomes entirely closed. Sometimes, however, the process of obliteration is more or less incomplete. Should it fail altogether, a portion of the abdominal viscera may pass into the tunica vaginalis, and constitute the congenital variety of inguinal hernia; or peritoneal fluid may accumulate in the testicular sac and form a congenital hydrocele. More frequently the continuity of the tunica vaginalis with the peritoneum is interrupted; but a slender pouch of peritoneum, the **processus vaginalis,** may run into the inguinal canal, and even through the external ring into the cord, or the tunica vaginalis may be prolonged upwards upon the cord for a considerable distance.

Should any portion of the abdominal contents enter the processus vaginalis, it may pass through the inguinal canal as a hernia, and descend into the scrotum. If at the same time the upward extension of the tunica vaginalis be present, the hernia with its sac may pass within it or invaginate it, and a surgeon called upon to operate in such a case would probably open the tunica vaginalis before reaching the peritoneal sac, and thus meet with three layers of serous membrane before exposing the extruded intestine. A hernia of this kind is called 'infantile.' Cystic tumors may be formed by the distension of small unobliterated segments of the funicular portion of the tube, and are called encysted hydroceles of the cord.

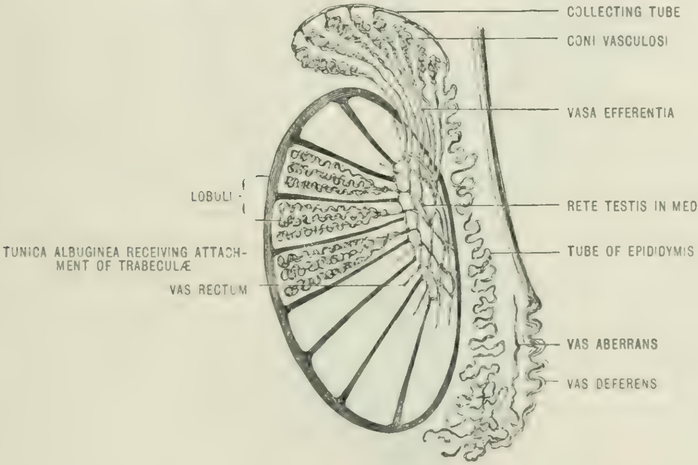
Structure (fig. 623).—The **testicle proper** consists of a tubular parenchyma enclosed within a strong fibrous tunic, the **tunica albuginea.**

The **tunica albuginea** (figs. 621, 623) is a dense, white, inelastic capsule of about one-twenty-fifth of an inch (1 mm.) in thickness in the greater part of its extent, but reaching two or three times this admeasurement beneath the epididymis where it forms the **mediastinum testis,** or **Corpus Highmorianum.** It is perforated at its upper and back part by the efferent seminal tubes which go to form the globus major of the epididymis, and from its inner surface pass a number of sustentacular processes, in the form of thread-like fibro-muscular filaments and delicate septal planes of connective tissue, the **trabeculæ.** The **mediastinum** extends forwards from the upper half of the posterior border, occupying about a fourth of the sagittal and a third of the transverse diameter of the interior, and is tunnelled by blood-vessels and a network of seminal tubes (the **rete testis**). The **trabeculæ** radiate from the deep aspect of the mediastinum to the inner surface of the tunica albuginea, and subdivide the interior of the capsule into a number of loculi (150–200).

Within these loculi lie the testicular tubules, supported by a fine retiform connective tissue, which becomes condensed into a highly vascular lamina called the **tunica vasculosa,** where it is in contact with the albuginea. The proper secreting substance consists of fine branching and anastomosing canals, the **tubuli seminiferi,** about $\frac{1}{125}$th of an inch (.2 mm.) in diameter, and lined with a layer of cubical cells in which are developed the spermatic filaments or **spermatozoa.** The tubules are collected into little bundles, called **lobules,** about three hundred in number, each comprising two or more separate tubes. The number of these lobules is variously estimated (300–400), and the total length of the component tubules has been calculated roughly at about nine hundred yards. By the union of the tubules of the different lobules are formed a number of larger tubes, the **tubuli recti,** which converge towards the mediastinum, and on entering it break up into a plexus, the **rete testis**; from the rete in turn spring twelve to twenty efferent tubes, or **vasa efferentia,** twice or three times as large as the tubules, and these, piercing the upper and back part of the albuginea, end in the head of the epididymis (fig. 623).

The epididymis, representing the second stage in the course of the seminiferous vessels, is invested by a tunica albuginea continuous with that of the testicle proper, but of much greater tenuity. The vasa efferentia, after their escape from the testicle proper, form each a tube about six to eight inches in length, lined with ciliated epithelium and coiled in such a manner as to assume the form of a conical mass, the **conus vasculosus,** with the apex towards the albuginea. The **coni vasculosi** grouped together constitute the globus major, and their respective tubules are collected by a single canal, the **tube of the epididymis,** which by its complex coils, fifteen to twenty feet in length, makes up the body and globus minor of the epididymis, and finally terminates in the free portion of the duct, the **vas deferens.** It presents near its termination one or more diverticula, the largest and most constant of which, the **vas aberrans** of Haller, ranges from an inch and a half to fifteen inches in length, and runs up between the body of the epididymis and the commencement of the vas deferens. The tube of the epididymis, like those of the coni vasculosi, is lined with ciliated epithelium, but its walls are thick, and contain two layers of unstriped muscular fibres.

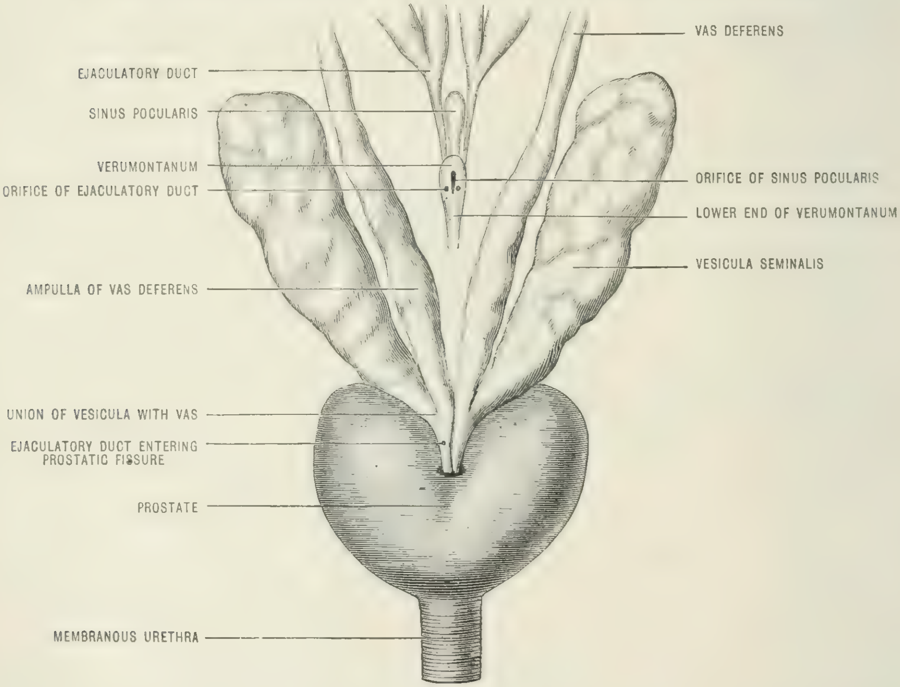
FIG. 623.—DIAGRAM OF THE TESTICULAR TUBULES.



Two little bodies of some morphological interest are to be found appended to the testicle proper and the globus major. The less constant of these, known as the **hydatid of Morgagni,** is a pediculated sac from one-eighth to one-third of an inch in length, dilated at its free extremity and containing a clear fluid; the other, rarely absent, has about the same dimensions, but is usually sessile and flattened, and may be subdivided into two or three lobes. It is believed to correspond to the upper end of the Fallopian tube, and to be a relic of the Müllerian duct (page 1057), the fœtal structure from which are developed the most important parts of the internal genitals of the female.

Another relic, called the **paradidymis,** or **organ of Giraldès,** probably derived from the Wolffian body (page 1056), is seen over the lowest portion of the spermatic cord immediately above the head of the epididymis. It consists of coiled tubules, blind and dilated at both ends, lying beneath the visceral layer of the funicular portion of the tunica vaginalis. It usually has the appearance of a white or yellowish irregular patch about one-fifth of an inch in diameter. Any of these embryonic structures may give rise to cystic tumors, and the aberrant tubes are probably not an uncommon source of origin of true spermatic cysts containing seminal fluid.

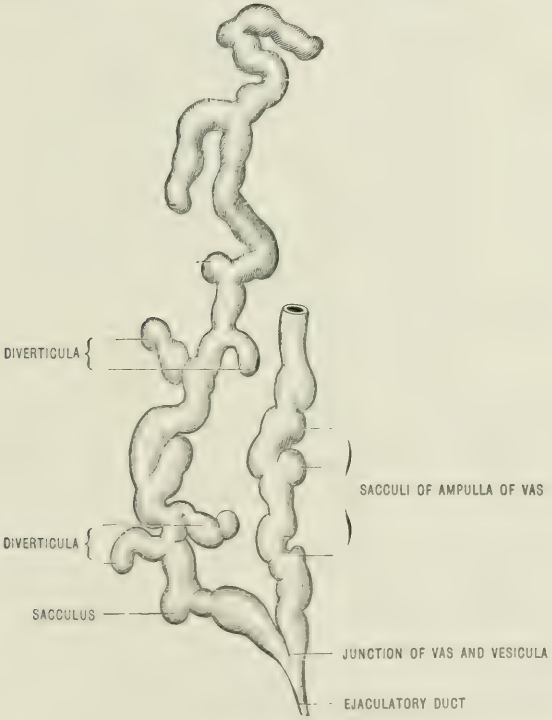
FIG. 624.—VASA DEFERENTIA AND VESICULÆ SEMINALES. (After Sappey.)


VAS DEFERENS
EJACULATORY DUCT
SINUS POCULARIS
VERUMONTANUM
ORIFICE OF EJACULATORY DUCT
ORIFICE OF SINUS POCULARIS
LOWER END OF VERUMONTANUM
VESICULA SEMINALIS
AMPULLA OF VAS DEFERENS
UNION OF VESICULA WITH VAS
EJACULATORY DUCT ENTERING PROSTATIC FISSURE
PROSTATE
MEMBRANOUS URETHRA

The testicle remains small until the period of puberty, and then, together with the penis and prostate, it begins to undergo rapid development; but in some cases its evolution is arrested before it has attained its full dimensions, and this is particularly liable to occur when its descent into the scrotum has been intercepted, or when a varicose dilatation of its veins appears before adolescence. In old age it usually loses much of its functional activity, but this is not invariably the case.

The **VAS DEFERENS** is the continuation of the tube of the epididymis, and extends from the globus minor to the prostatic portion of the urethra. In the lower part of its course it is slender and tortuous, but it becomes thicker and straighter as it ascends along the back of the epididymis (testicular stage), and attains its full size before it reaches the top of the organ. From this point it is the principal element of the spermatic cord, and runs upwards almost vertically as far as the external inguinal ring (funicular stage); entering the inguinal canal, it runs obliquely outwards, upwards, and slightly backwards to the internal ring (inguinal stage). It then quits the associated vessels of the cord, and, winding around the origin of the deep epigastric artery to the inner side of the external iliac artery and in front of the external iliac vein, enters the pelvis (pelvic stage) close to the iliopubic suture, and runs downwards and backwards over the side of the bladder, crossing it on the vesical side of the obliterated hypogastric artery and ureter, to reach the side of the posterior wall of the viscus. Here it lies between the bladder and the second stage of the rectum, and, becoming enlarged and sacculated, passes downwards and inwards towards the base of the prostate, where it narrows and is joined by the lower end of the vesicula seminalis. The common tube descends as the **ejaculatory duct,** to pierce the prostatic fissure and open into the prostatic portion of the urethra. The two vasa deferentia, where they lie in front of the rectum, are separated by a triangular interval, the apex of which is formed by the approximation of the ejaculatory ducts, and lies immediately above the prostate. The whole of the pelvic portion of the vas is subperitoneal except near its termination, where it is invested only by recto-vesical fascia and an extension of subperitoneal tissue.

FIG. 625.—VAS DEFERENS AND VESICULA SEMINALIS DISSECTED. (After Sappey.)



The entire length of the vas deferens averages about sixteen inches (40 cm.), of which an inch and a quarter (3 cm.) may be allotted to the testicular stage, three inches to the funicular stage, an inch and three-quarters to the inguinal stage, and the rest to the pelvic stage. It is cylindrical and of uniform diameter (about one-tenth of an inch) in its funicular, inguinal, and pelvic stages down to the retrovesical portion, and its walls are of great thickness, about one-twenty-fifth of an inch (1 mm.), while its calibre is extremely small. It is here composed of an outer cellular coat containing vessels and smooth muscular fibres, a threefold muscular coat with external and internal longitudinal and middle circular layers, and a mucous membrane lined with cylindrical epithelium. The ampullated retrovesical portion differs from the rest in the thinness of its walls and in its sacculation, and in these respects approximates to the vesiculæ seminales (fig. 625).

The **VESICULÆ SEMINALES** are two diverticular reservoirs situated between the bladder and rectum external to the ampullæ of the vasa deferentia.

Each vesicula is of somewhat triangular form, its broad upper extremity lying beneath the peritoneum, its apex joining the vas deferens at the base of the prostate. It averages about two and a quarter inches (6 cm.) in length and half an inch (12 mm.) in diameter at its base. It is lobulated on the surface, and on dissection is found to consist of a central tube from three to five inches (8–12 cm.) in length, with two or more short lateral branches. It is related *in front* to the posterior wall of the bladder, and by its upper extremity overlaps the ureter: *posteriorly* it is covered by the recto-vesical pouch of peritoneum, for a short distance above; and below this point it lies in direct contact with the front of the rectum, and external to the ampulla of the vas deferens. It becomes constricted at its junction with the vas. Structurally it consists of a fibrous external coat, a middle muscular coat, and an internal mucous membrane. The muscularis is arranged in three layers, the inner and outer of which are longitudinal in direction, the intermediate fibres being transverse.

The mucous membrane is plicated, sacculated, yellowish-brown in colour, and lined with cylindrical epithelium. It is invested, together with the ampulla of the vas, by a kind of sheath of fibrous tissue and by a layer of smooth muscular fibres which is probably accessory in function to the contractile element of the proper wall of the tubes.

The **EJACULATORY DUCT**, formed on each side by the union of the vas deferens and vesicula seminalis, is an infundibuliform tube about $\frac{3}{4}$ of an inch in length, and about $\frac{1}{8}$ of an inch (3 mm.) in width above, narrowing to $\frac{1}{3}$ of that size below, while the lumen near its opening is not more than $\frac{1}{50}$ of an inch (0·5 mm.) in diameter. The two ducts converge slightly as they descend, and finally, passing behind the so-called 'middle lobe,' the hinder part of the basal muscular ring of the prostate (page 1022), pierce the prostatic fissure and open on to the verumontanum on either side of the orifice of the sinus pocularis (fig. 624).

Vessels and Nerves of the testicle and its appendages.—The testicle is supplied with blood by the spermatic and deferential **arteries,** the two vessels anastomosing with each other and with the scrotal arteries at the lower extremity of the gland. The corresponding **veins,** spermatic and deferential, form like communications and run up in two separate groups. The spermatic veins, large and imperfectly valved, spring from the upper part of the testicle, and, running in front of the deferential veins around the spermatic artery, are connected to each other by means of short transverse branches; finally, the right ends in the vena cava, the left in the left renal vein. The **lymphatics of the vas** and **testicle** accompany the veins. The former terminate in the pelvic iliac glands, the latter in the lumbar glands.

The free anastomosis between the deferential, spermatic, and scrotal blood-vessels explains why the ligature or excision of the spermatic veins and artery in varicocele leaves the nutrition of the testicle unimpaired; while the intercommunication of the testicular and scrotal blood and lymph vessels behind the epididymis accounts for the extension of inflammatory affections of the epididymis to the scrotal integument.

The **Nerves** of the testicle come from the aortic, renal, and hypogastric plexuses.

The vesicula seminalis is supplied by the deferential, inferior vesical, and middle hæmorrhoidal **arteries**: its veins, large and numerous, form a kind of plexus which receives some of the vesical veins, and communicates below and in front with the prostatic plexus: its **lymphatics** end in the pelvic glands, and the **nerves** are derived from the hypogastric plexus.

SPERMATIC CORD

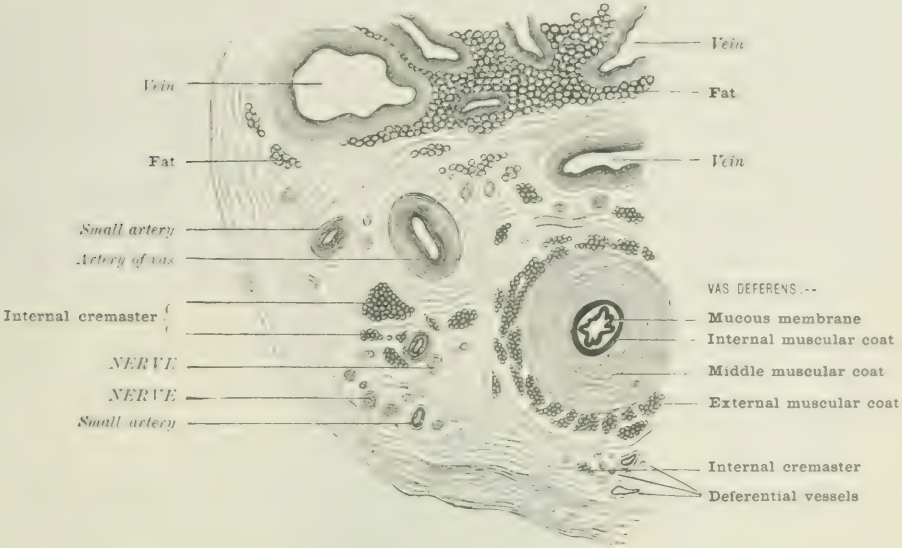
The **spermatic cord** is the elongated pedicle of the testicle. It extends from the internal inguinal ring, where its component structures are collected together, through the inguinal canal, and into the scrotum as far as the summit of the testicle. Its constituent elements are as follow (fig. 626).

1. The **vas deferens,** lying with the deferential vessels posterior to the other structures, and recognisable by its cord-like resistance to pressure.

2. The **spermatic artery.**
3. The **spermatic veins,** or pampiniform plexus, surrounding the artery.
4. **Lymphatics** running with the veins.
5. **Sympathetic nerves** accompanying the artery.

6. The **processus vaginalis,** occasionally seen as a thread-like relic of the tube of communication between the tunica vaginalis and peritoneum. It is frequently patent for a short distance near the internal inguinal ring, and probably accounts in great part for the insidious development of hernial protrusions in this region.

Fig. 626.—Section of the Spermatic Cord. (After Henle.)



7. The **internal cremaster** of Henle. Scattered bundles of smooth muscular fibres, said to represent the inverted lateral bands of the gubernaculum testis.

8. **Fat** and **connective tissue,** continuous above with the subperitoneal planes of fascia. Inguinal or scrotal lipomata or fibromata may take origin from these elements and may simulate true hernias.

In the scrotum these various structures are invested by coverings identical with those of the testicle.

THE PENIS

The **penis** is composed of three rod-like segments of erectile tissue, firmly united together and invested by a sheath composed of integument, dartos, and fascia (fig. 627).

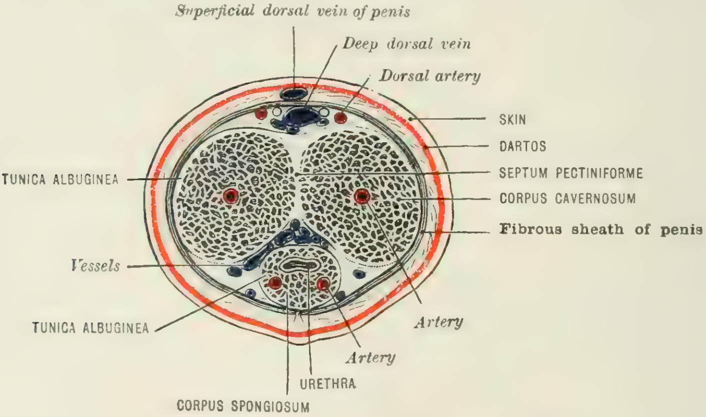
Of these three erectile segments, two, the **corpora cavernosa,** are placed side by side above or dorsally; the third, the **corpus spongiosum,** is perforated in the whole length by the urethral canal, and lies on the ventral aspect of the former, except where it expands distally to form the free end of the organ (fig. 628).

The penis as a whole may be divided into a root, a body, and a terminal enlargement or glans; the **root** is attached to the symphysis and pubic arch; the **body,** prismatic, with rounded angles in section, forms the greater part of the free portion of the organ; and the **glans** is a heart-shaped expansion, more developed on its dorsal than on its ventral aspect, and presenting the urethral orifice at its distal extremity. The body and glans are separated by a constriction called the **neck.**

The **coverings of the penis** are continuous with those of the testicle. The skin, like that of the scrotum, is pigmented and highly elastic, and unlike the skin over the rest of the body, is devoid of smooth muscular fibres and subcutaneous fat. It contains large sebaceous glands, which in the neighbourhood of the neck of the organ secrete a whitish fatty odourous substance, the **smegma præputii.** It moves freely upon the subjacent parts except over the glans, where it is firmly adherent. At the neck it becomes peculiarly redundant, and forms a fold, the **prepuce,** which more or less completely conceals the glans. The deeper layer of the duplicature, which is turned towards and is continuous with the skin of the glans, is sometimes termed 'mucous membrane,' which it resembles only in the absence of hairs and sudoriparous glands. A small median plication, the **frænum præputii,** extends from the prepuce to the lower surface of the glans. This contains vessels of some size, and, if ruptured, may give rise to considerable loss of blood. The preputial orifice is usually large enough to allow the easy retraction of the fold, but sometimes is congenitally constricted, and prevents the exposure of the glans (phimosis). Owing to the composition of the prepuce by two layers of integument, the removal of a complete ring as in the ordinary operation for phimosis impedes the passage of the lymph and blood from the portion left attached to the glans, and hence considerable infiltration of this part may result.

The **dartos** is continuous with the dartos tissue (page 1023) of the scrotum, and consists of smooth muscle, the fibres of which are for the most part disposed longitudinally. It enters into the formation of the prepuce, and according to Sappey forms a kind of sphincter around the preputial orifice. Beneath the dartos is a loose elastic **connective-tissue layer** containing the superficial vessels and nerves of the penis, and very liable to infiltration in inflammatory or dropsical conditions and in urinary extravasation. Beneath this lies the **fascial sheath** of the penis, a complete and highly elastic tunic investing the entire organ as far as the base of the glans, where it fuses with the integument. It is also adherent both to the skin and to the corpus spongiosum along the ventral raphe, and it covers the deep dorsal vessels and nerves and the lateral tributaries which converge to the dorsal vein. This sheath, aided by the dartos and certain processes from the bulbo-cavernosi and ischio-cavernosi muscles, compresses the veins of the penis.

FIG. 627.—TRANSVERSE SECTION THROUGH THE BODY OF THE PENIS.



The **suspensory ligament** of the penis is a strong band of fibrous tissue which passes from the front of the symphysis to the subjacent portion of the organ, blending with the fascial sheath in the middle line and at the sides, and continued into the septum scroti below. The **angle of the penis** corresponds to the most anterior point of suspension to the symphysis.

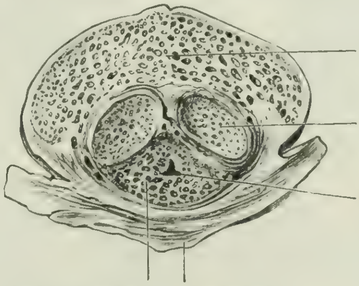
The **corpora cavernosa** constitute the dorsal and larger part of the penis. They are closely united in the greater part of their extent, but separate a short distance in front and diverge somewhat widely behind. The posterior extremity of each, called the **crus penis,** at first enlarges slightly, but tapers as it approaches the subpubic arch; then, becoming tendinous and somewhat flattened, is strongly attached to the ischio-pubic rami; and the distal end, pointed somewhat like the tip of a cigar, is plunged into the substance of the glans (fig. 628). The entire length of the corpus cavernosum averages about six inches, and its breadth about half an inch, but it increases in size by one-third or more when its vascular spaces are fully distended.

In structure it consists of a sponge-like erectile tissue invested by a strong sheath or **tunica albuginea.** The sheath is about a line in thickness, white, remarkably tough, and consists of two laminæ, an external, of longitudinal fibres common to both corpora cavernosa; and an internal, of circular fibres surrounding each corpus and forming a mesial **septum pectiniforme** where the two corpora cavernosa come into contact. The framework of the cavernous structure is formed by a reticular arrangement of fibro-muscular trabecular bands, starting from the inner surface of the albuginea and becoming more slender as they approach the axis of the body. The branches of the supplying artery run in the trabeculæ and terminate by opening into the anastomosing intertrabecular spaces which represent the widely dilated capillaries of the organ.

The **corpus spongiosum** lies in the middle line and below the united corpora cavernosa. Unlike the latter it has no direct attachment to the pelvic bones, but terminates at each end in a bulbous expansion. It may be divided into a glans, a body, and a bulb.

The anterior enlargement, or **glans,** is somewhat heart-shaped, its base extending much farther over the dorsal than over the ventral aspect of the corpora cavernosa, and showing a distinct indication of division into two lateral lobes in the latter situation. The most prominent part of the base is called the **corona glandis,** and the groove behind this is the **neck** of the penis or balano-preputial furrow. At its tip it presents a vertical fissure about one-third of an inch in length, the **external urinary meatus** or outlet of the urethra.

Fig. 628.—Transverse Section of the Penis through the Base of the Glans.


CORPUS SPONGIOSUM (GLANS)
DISTAL EXTREMITY OF CORPUS CAVERNOSUM
URETHRA
CORPUS SPONGIOSUM
Integument

The glans is composed of erectile tissue with coarse trabeculæ, and is covered with a firmly adherent layer of skin continuous with the inner layer of the prepuce. Its capacity for vascular engorgement is much less than that of the corpus cavernosum or the rest of the corpus spongiosum, and it does not attain a like degree of hardness during erection.

The structural continuity of the glans with the corpus spongiosum is probably not morphological. The recent investigations of Retterer indicate that the greater portion of the glans is developed separately as a part of the cutaneous and fibrous envelope of the penis, and becomes erectile as a later change.

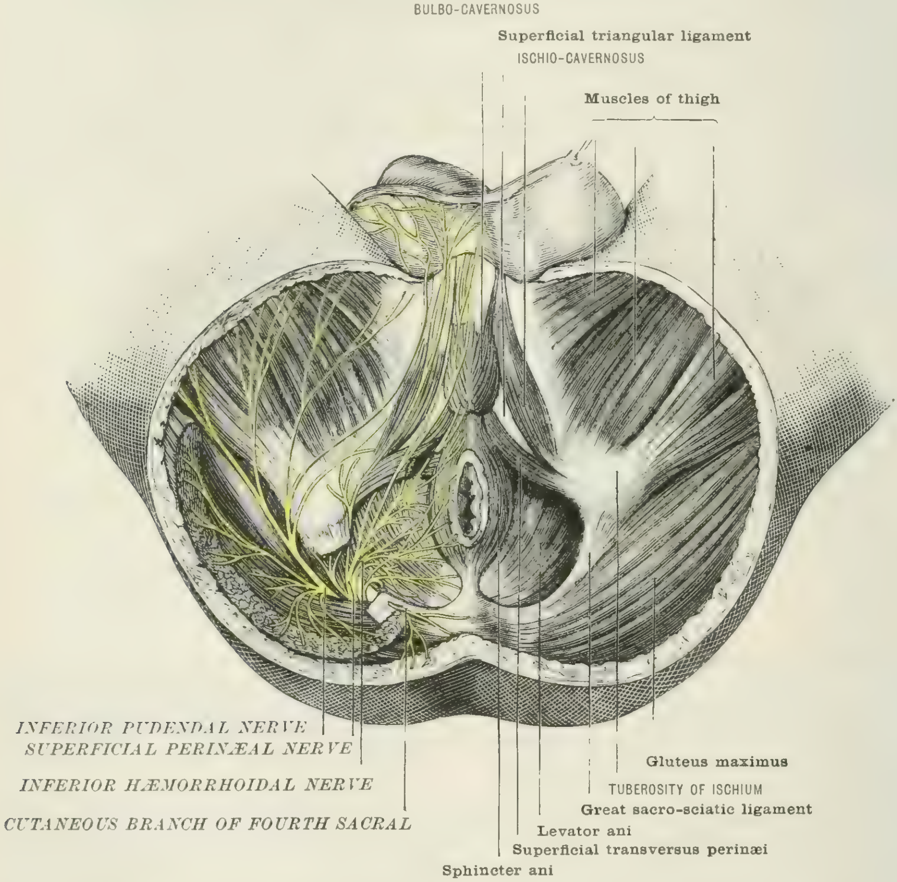
The **body** of the corpus spongiosum is cylindrical, uniform in diameter, and traversed axially in its whole length by the urethra; it is lodged above in a groove between the two corpora cavernosa, while its ventral aspect is subcutaneous except where it corresponds to the attachment of the scrotum. Structurally it is provided with a thin albuginea, between which and the urethra lies a narrow layer of erectile tissue.

The **bulb** is formed by an expansion of the erectile structure, and the portion of the urethra by which it is traversed undergoes a well-marked dilatation, and lies nearer its upper than its lower surface. It is about an inch and a half in length, and its greatest width is about three-quarters of an inch. It is surrounded by the bulbo-cavernosi muscles, the greater part of the fibres of which pass between it and the corpora cavernosa to blend together in the middle line; and it rests posteriorly against the superficial triangular ligament about half an inch in front of the anus. It is liable to considerable enlargement after middle age.

Muscles.—The muscles of the penis are three on each side—the ischio-cavernosus, the bulbo-cavernosus, and the superficial transversus perinæi (fig. 629).

The **ischio-cavernosus** (**erector penis**) arises from the inner surface of the tuberosity and ramus of the ischium, from the pubic ramus, and from the adjacent root of the crus penis, and is inserted into the surface of the tunica albuginea of the corpus cavernosum near the point of attachment of the suspensory ligament. A slip, the **compressor venæ dorsalis,** is occasionally detached from its more distal portion, and becomes inserted into the fascial sheath of the penis over the dorsal vessels, or may blend with its fellow in a narrow tendon in this situation.

FIG. 629.—THE MALE PERINÆUM. (Modified from Hirschfeld and Leveillé.)


BULBO-CAVERNOSUS
Superficial triangular ligament
ISCHIO-CAVERNOSUS
Muscles of thigh
INFERIOR PUDENDAL NERVE
SUPERFICIAL PERINÆAL NERVE
INFERIOR HÆMORRHOIDAL NERVE
CUTANEOUS BRANCH OF FOURTH SACRAL
Gluteus maximus
TUBEROSITY OF ISCHIUM
Great sacro-sciatic ligament
Levator ani
Superficial transversus perinæi
Sphincter ani

The **bulbo-cavernosus** (**accelerator urinæ**) arises from a median raphe which extends from the anterior extremity of the sphincter ani along the whole length of the bulb as far as the level of the symphysis. A few of its more posterior fibres pass outwards to become inserted into the superficial triangular ligament and into the bulb, and a bundle of its most anterior fibres, muscle of Houston, may, like the similar slip from the ischio-cavernosus, form a sling around the corpora cavernosa and become attached to the fascial sheath of the penis, or it may be inserted into the side of the corpus cavernosum itself. In the former case it acts as a compressor of the dorsal vein. The rest of the fibres pass around the bulb to become lost in the connective tissue on the dorsal aspect of the latter, between it and the corpora cavernosa; the two muscles thus practically encircle the bulb, and act as an annular sphincter upon the contained portion of the urethra. It is often joined by fibres from the sphincter ani and deep transversus perinæi.

The **superficial transversus perinæi** is the most variable of all the perinæal muscles. It usually arises from the inner surface of the tuberosity and ramus of the ischium, blending with the origin of the ischio-cavernosus, and passes inwards and forwards to its insertion into the tendinous centre of the perinæum, interlacing with the posterior fibres of origin of the bulbo-cavernosus. Some of its fibres may blend with those of the sphincter ani and levator ani.

These three pairs of muscles possess each a thin fascial sheath, and lie in the superficial perinæal interspace between the fascia of Colles and the superficial triangular ligament. They are supplied by branches of the deep division of the superficial perinæal nerves and vessels.

The *action* of the penile muscles is not very obvious. The compressores venæ dorsalis when present may aid in erection by impeding the return of venous blood from the organ, but there is no reason to believe that any disadvantage attaches to their absence. The bulbo-cavernosus, with its fellow, is, however, of value as a compressor of the bulbous portion of the urethra, and thus assists in the ejaculation of the semen, continuing the action of the ejaculatory fibres of the prostate and of the deep transversus perinæi; and it may also be of service in expelling the last drops of the urine. The compression of the vessels of the bulb favours the engorgement of the rest of the corpus spongiosum.

The ischio-cavernosus in the absence of its dorsal fasciculus can scarcely justify its older name of erector penis, but it appears to have the power of impressing voluntary movements upon the turgid organ. The superficial transversus perinæi is accessory to the bulbo-cavernosus, fixing the raphe from which its fibres arise, and it adds slightly to the strength of the muscular floor of the pelvis.

Vessels and Nerves of the Penis.

Artery.—The envelopes of the penis are supplied by the external pudic, the superficial perinæal, and the dorsal artery; the first from the femoral, the others from the internal pudic. The corpora cavernosa are supplied by the cavernous branch of the pudic; the corpus spongiosum by the special artery of the bulb (internal pudic) and the dorsal artery.

Veins.—The veins of the coverings of the penis end in one or two superficial dorsal veins which run in the connective tissue layer between the dartos and fascial sheath, and end in the long saphenous and femoral veins. The deep veins of the corpora cavernosa and corpus spongiosum terminate partly in the plexus of Santorini (chiefly through the deep dorsal vein), and partly in the internal pudic. They communicate freely with each other and with the superficial veins.

Lymphatics.—The lymphatics run with the veins, those of the coverings being collected by superficial dorsal trunks which pass to the inguinal glands. The deep lymphatics from the corpora cavernosa and corpus spongiosum for the most part join a dorsal cord which runs with the deep dorsal vein to end in the inguinal glands; a few probably reach the pelvic and lumbar glands.

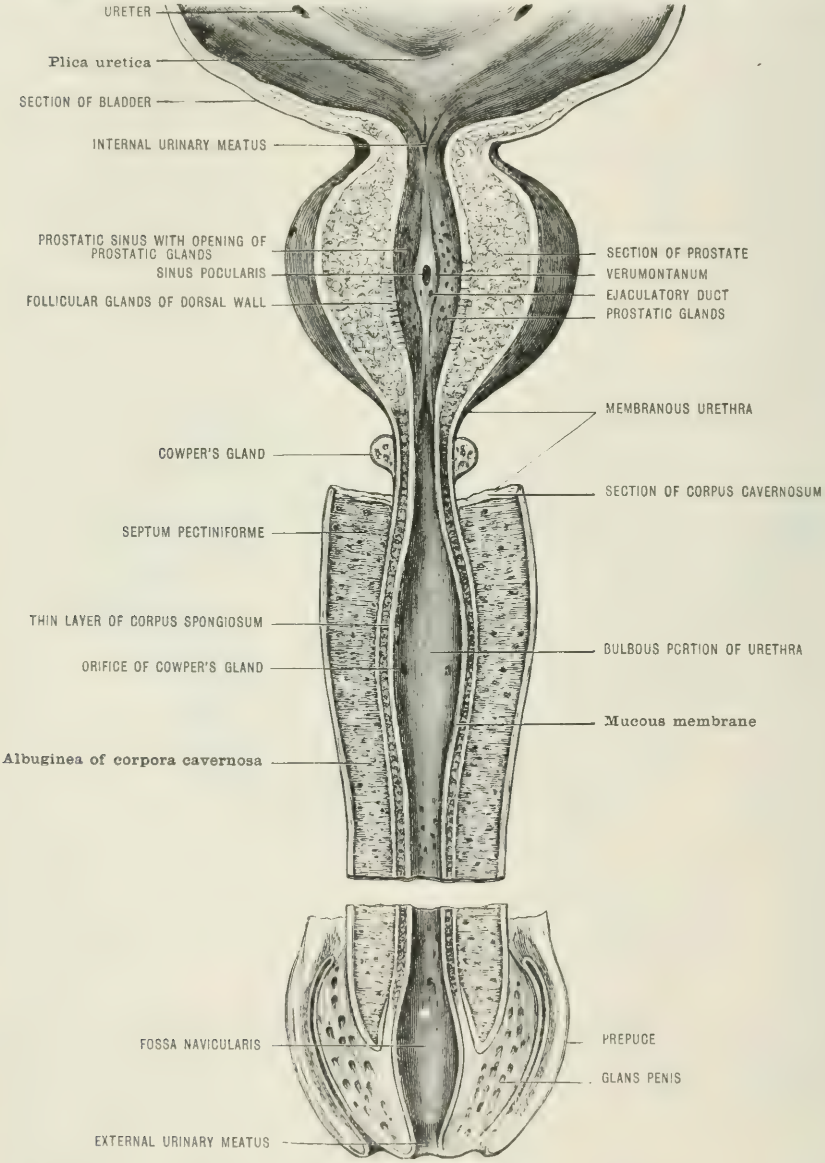
Nerves.—The integumentary structures are supplied by the genital branch of the genito-crural and the superficial perinæal branches of the pudic. The erectile bodies receive filaments from the dorsal nerve of the penis, the superficial perinæal, and the hypogastric plexus.

THE URETHRA

The **urethra** is the mucous canal extending from the bladder to the extremity of the glans penis. In its course it pierces the prostate from base to apex, the deep and superficial triangular ligaments with the intervening compressor urethræ, and the whole length of the corpus spongiosum. It may hence be divided into three segments:—(1) Prostatic; (2) membranous (the portion lying in the space between the two transverse ligaments); and (3) spongy (fig. 630).

The prostatic portion runs almost vertically downwards from the internal urinary meatus, but with a slight forward inclination below; the membranous portion and the posterior part of the spongy portion as far as the anterior border of the suspensory ligament of the penis describe a curve beneath the symphysis; lastly, the portion of the spongy urethra, beyond the penile angle, follows the direction of the pendent portion of the penis and necessarily follows the movements of that organ.

FIG. 630.—THE MALE URETHRA, CLEFT DORSALLY TO SHOW VENTRAL MUCOUS WALL.


URETER
Plica uretica
SECTION OF BLADDER
INTERNAL URINARY MEATUS
PROSTATIC SINUS WITH OPENING OF PROSTATIC GLANDS
SINUS POCULARIS
FOLLICULAR GLANDS OF DORSAL WALL
SECTION OF PROSTATE
VERUMONTANUM
EJACULATORY DUCT
PROSTATIC GLANDS
MEMBRANOUS URETHRA
COWPER'S GLAND
SECTION OF CORPUS CAVERNOSUM
SEPTUM PECTINIFORME
THIN LAYER OF CORPUS SPONGIOSUM
BULBOUS PORTION OF URETHRA
ORIFICE OF COWPER'S GLAND
Mucous membrane
Albuginea of corpora cavernosa
FOSSA NAVICULARIS
PREPUCE
GLANS PENIS
EXTERNAL URINARY MEATUS

Its average length is still variously stated by different authorities, but the investigations of Cazenave and Sappey, confirmed as they are by the frozen sections of Braune and others, set the matter at rest so far as the physiological condition is concerned. In the ordinary relaxed state of the penis the distance between the internal and external meatus does not usually exceed six inches and a half (16 cm.), and may be less than this when the organ is contracted to its minimum degree. But under the test of catheterism the length of the canal is undoubtedly greater, and may reach seven or eight inches (18–20 cm.) or even more, owing to the traction upon the penis which accompanies the operation. The canal may be greatly lengthened also by senile hypertrophy of the prostate, which carries the internal meatus upwards towards the level of the top of the symphysis.

The diameters of the passage are scarcely capable of accurate measurement. In the ordinary condition it is represented by a fissure, and its limits of safe dilatability can only be approximately calculated. Otis's investigations show that these limits are wider than was formerly believed to be the case, and he has endeavoured to establish as a law that there is a ratio between the maximum circumference of the canal and that of the penis, of four to nine. Thus a penis having in its ordinary state a circumference of thirty-six lines should possess a urethra capable of admitting an instrument of sixteen lines. The sources of fallacy in such an observation are not inconsiderable, but they do not destroy its value as a practical guide to the surgeon.

The **prostatic portion** is about an inch and a quarter (3 cm.) in length, wider in the middle than at the two extremities, and almost perpendicular in direction, with a slight inclination downwards and forwards at its lower end. Its anterior wall is concave both in longitudinal and transverse sections, and is studded with the orifices of small mucous follicles; the posterior wall presents a longitudinal ridge called the **colliculus seminalis** or **verumontanum**, highest near the middle and gradually diminishing above and below. A little above the centre of the colliculus may be seen a rather large opening which leads to a *cul-de-sac* of especial interest for the morphologist, the **sinus pocularis** or **uterus masculinus**, and on the lateral margins of the orifice of the sinus are seen two small puncta, one on each side, the openings of the **ejaculatory ducts.** The sinus pocularis and ducts may be traced upwards and backwards through the prostatic cleft and behind the sphincteric fibres which constitute the prostatic bar or middle lobe of the prostate.

In consequence of the presence of the colliculus the urethral fissure appears on horizontal section as a **U**-shaped curve with forward convexity. The recesses corresponding to the extremities of the **U** are sometimes called the **prostatic sinuses,** and into these open the orifices of the posterior and lateral prostatic glands.

The *mucous membrane* of the prostatic urethra is lined with a laminated epithelium. Beneath this is a layer of erectile tissue which constitutes the principal element of the colliculus, and is in turn supported by a layer of longitudinal muscle.

The **sinus pocularis** is believed to be the homologue of the uterus. It is about half an inch in length, and terminates by a blind, slightly dilated extremity. Its walls consist of connective tissue intermingled with smooth muscular fibres, and covered with laminated epithelium. It contains a few simple or compound glands, in which small concretions are occasionally found.

The **membranous portion,** bounded above and below by the superior and inferior triangular ligaments, is about half an inch (12 mm.) in length; it is inclined downwards and somewhat forwards, and lies about an inch (25 mm.) behind the subpubic ligament, from which it is separated by the muscular fibres of the deep transversus perinaei and a plexus of veins. It is closely related on either side to Cowper's glands.

The *mucous membrane* resembles that of the prostatic urethra in its epithelium and erectile layer and muscularis, but surrounding these structures is a strong annular band of unstriped muscle continuous with the fibres of the prostate and forming a sphincter of considerable power. This in turn is supported by the striated fibres of the deep transversus perinaei. The glands of the mucous membrane, simple and racemose, form suite with those of the anterior wall of the prostatic canal.

The **spongy portion** extending to the extremity of the penis presents two dilatations with an intermediate portion of narrow but uniform dimensions. The posterior expansion (**pars bulbosa**) lies in the bulb, and is about an inch (25 mm.) in length; the anterior (**fossa navicularis**) is of nearly the same extent, and is situated within the glans. The **penile angle,** formed where the flaccid organ falls from the point of suspension at the pubic region, lies about two inches (5 cm.) in front of the superficial triangular ligament; and the portion of the canal behind this is almost horizontal in direction, but with a slight upward concavity (fig. 617).

The *mucous membrane* of the spongy urethra contains a large quantity of elastic tissue and is lined by a laminated epithelium, the superficial cells of which are prismatic in form, while the deeper layers cover in rows of more or less longitudinally disposed papillæ. At its distal extremity the integumental covering of the glans is inflected for about a quarter of an inch (6 mm.), the line of demarcation between the cutaneous and mucous structures being well defined. The **external meatus** is represented by a vertical slit about a quarter of an inch (6 mm.) in length, and is the least dilatable part of the canal; hence in urethral operations it is sometimes necessary to enlarge it by incision.

An examination of the mucous surface will show a number of orifices arranged in three longitudinal rows extending along the dorsal wall, and leading to short tubular depressions which run in a backward direction (towards the bladder) and are called the *lacunæ of Morgagni*. One of these, termed the *lacuna magna* or *sinus of Guérin*, situated in the mesial line about an inch from the external meatus, is of large size, and may arrest the point of an instrument during catheterism. It is bounded by a little fold of mucous membrane, the valvule of Guérin, and may attain a depth of one-third of an inch (8 mm.). In addition to these are many simple and compound mucous glands, such as appear in the prostatic portion of the canal; and the ducts of Cowper's glands open into the anterior portion of the bulb on the ventral wall.

The muscular coat consists chiefly of longitudinal fibres continuous with those of the bladder, but a circular layer prolonged from the sphincteric fibres of the membranous urethra extends as an outer layer over the bulbous portion of the canal gradually disappearing beyond this point.

As already mentioned, the collapsed urethra is represented by a fissure. This in the glans penis is vertical in direction. A short horizontal branch is superadded at the upper end of the fossa navicularis, giving the fissure the aspect of an inverted **T**. Above this point the horizontal limb progressively elongates, while the vertical limb shortens until the former alone is left, and the rest of the spongy urethra is represented by a transverse fissure. In the membranous segment the fissure is usually stellate, while in the prostatic region the presence of the colliculus gives it the **U**-like form already described. This progressive change of shape involves a kind of rifling of the tube, and probably accounts for the spiral form of the normal stream of urine.

The muscular tissue of the urethra appears to be capable of a peculiar vermicular contraction by which a catheter left within the urethra is gradually expelled, and an example is known in which an elastic instrument insecurely tied *in situ* found its way, in the reverse direction, into the bladder, and formed the nucleus of a calculus.

The **female urethra** is described on page 1041.

THE FEMALE ORGANS OF GENERATION

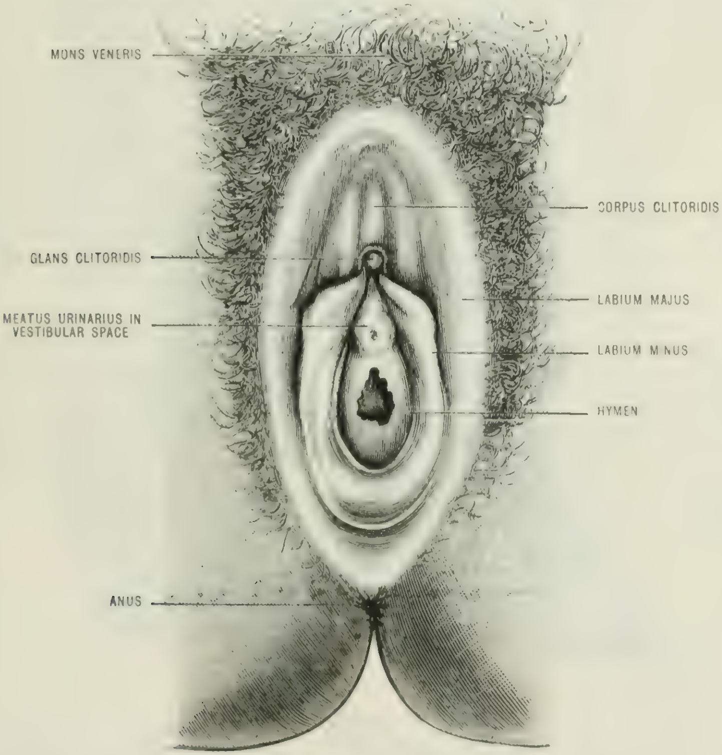
The **female genitals** may be divided into (1) an external part, the vulva, representative of structures found in a more highly developed condition in the male; (2) a vaginal passage, the cavity of which appears as a fissure in its ordinary condition, but is capable of very great dilatation; and (3) an internal apparatus comprising the organs of ovulation (ovaries) with their ducts, and a musculomucous sac (uterus) in which the ovum undergoes development, and by which the fœtus is ultimately expelled. The vagina and internal organs are intra-pelvic.

The **VULVA** consists of a pair of integumentary folds, the **labia majora**; two smaller folds, the **labia minora**; a small penile appendage, the **clitoris**; and a short passage, the **vestibule**, leading to the vaginal orifice. The vestibule is flanked on either side by an erectile body, the bulbus vestibuli, and pierced in the middle line by the urethra (fig. 631, 632).

The **labia majora** correspond morphologically to the scrotum in the male. They are two folds of integument about three inches in length, continuous above the symphysis, with an eminence called the **mons Veneris**, and meeting below in a **posterior commissure**, or **fourchette**, about an inch in front of the anus. Each labium has two surfaces: an outer, pigmented and covered with strong crisp hairs; an inner, in contact with its fellow, smooth, presenting only rudimentary hairs, but beset with large sebaceous follicles. The fissure between the two labia, called the **rima pudendi**, is horizontally placed in the erect posture.

The structures forming the labia resemble those of the scrotum, but the dartos is imperfectly developed, and each labium contains a well-defined encapsulated subcutaneous mass of fat, of somewhat ovoid shape, which blends above with the distal extremity of the round ligament. A similar mass is occasionally found in the male scrotum as a fatty tumour of the cord, and may simulate an inguinal hernia.

Fig. 631.—The External Genitals of the Female.



The **labia minora**, or **nymphæ**, are folds differing from the labia majora in their relatively small size and in the absence of hairs and fat. The two plications unite above, embracing the clitoris and forming the **præputium clitoridis**; below, they diverge and terminate opposite to or a little behind the middle of the rima genitalis. They are smooth and hairless on the surface, usually of a pale rose colour, and their free border, which projects for a very variable distance, is convex and often crenulated or lobed. They are usually concealed by the labia majora, except in the fœtus; but are sometimes largely developed, and may project beyond the genital fissure, then assuming a dry pigmented aspect. The sebaceous glands are large and occupy both surfaces. They are poorly developed until puberty, and attain their greatest size and activity during pregnancy.

The **vestibule** is the space between the labia minora and the vaginal orifice.

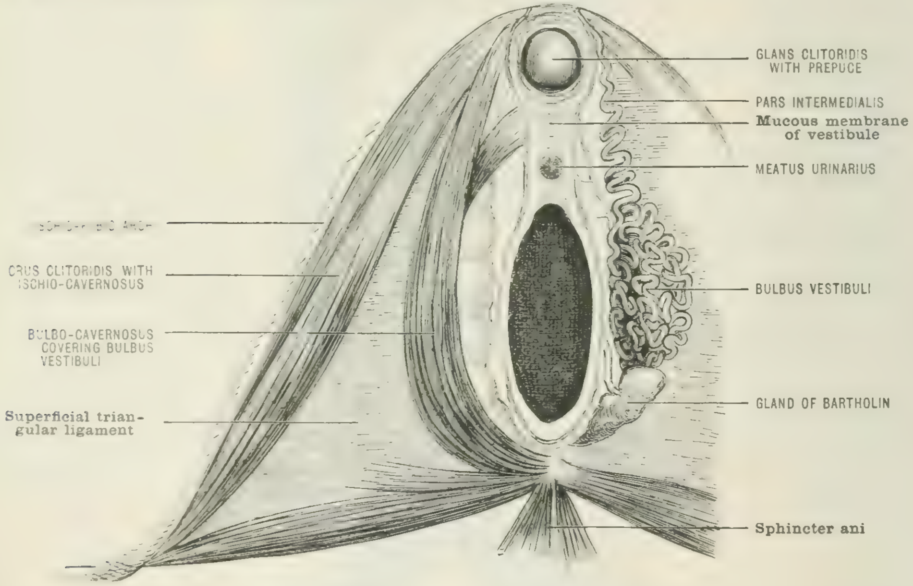
Its boundaries are ill defined posteriorly, and the term is used with different significance by different anatomists. Opening into it are the urethra, the glands of Bartholin, and a few glands of the same nature as those of the urethra, surrounding the external meatus.

The **glands of Bartholin** probably represent Cowper's glands in the male, but are more superficially placed. They are two little racemose glands, about a third of an inch long, situated one on either side beneath the lateral wall of the vestibule and behind the bulbi vestibuli. The duct, about three-quarters of an inch in length, opens immediately in front of the vaginal orifice opposite its meridian.

Vessels.—The vulvar structures are supplied by branches of the external and internal pudic arteries. The veins end in the corresponding trunks, and there is in addition a free anastomosis with the veins of the round ligament in the subcutaneous fat of the labium. The lymphatics terminate for the most part in the inguinal glands, a few passing to the femoral glands. About the vaginal orifice is a neutral territory in which the vulvar and vaginal absorbents intercommunicate.

The erectile structures of the vulva correspond morphologically to those of the male organ: the corpora cavernosa are represented by the clitoris, and the corpus spongiosum, cleft in the female by the vulvar orifice, appears beneath the mucous membrane of the vestibule in the form of two vascular plexuses, one on each side, called the bulbi vestibuli: and an indistinct mesial band extending from the clitoris to the meatus is believed by Pozzi to represent the anterior part of the corpus spongiosum.

Fig. 632.—Diagrammatic Representation of the Perinæal Structures in the Female.


GLANS CLITORIDIS WITH PREPUCE
PARS INTERMEDIALIS
Mucous membrane of vestibule
MEATUS URINARIUS
ISCHIO-PUBIC ARCH
CRUS CLITORIDIS WITH ISCHIO-CAVERNOSUS
BULBUS VESTIBULI
BULBO-CAVERNOSUS COVERING BULBUS VESTIBULI
GLAND OF BARTHOLIN
Superficial triangular ligament
Sphincter ani

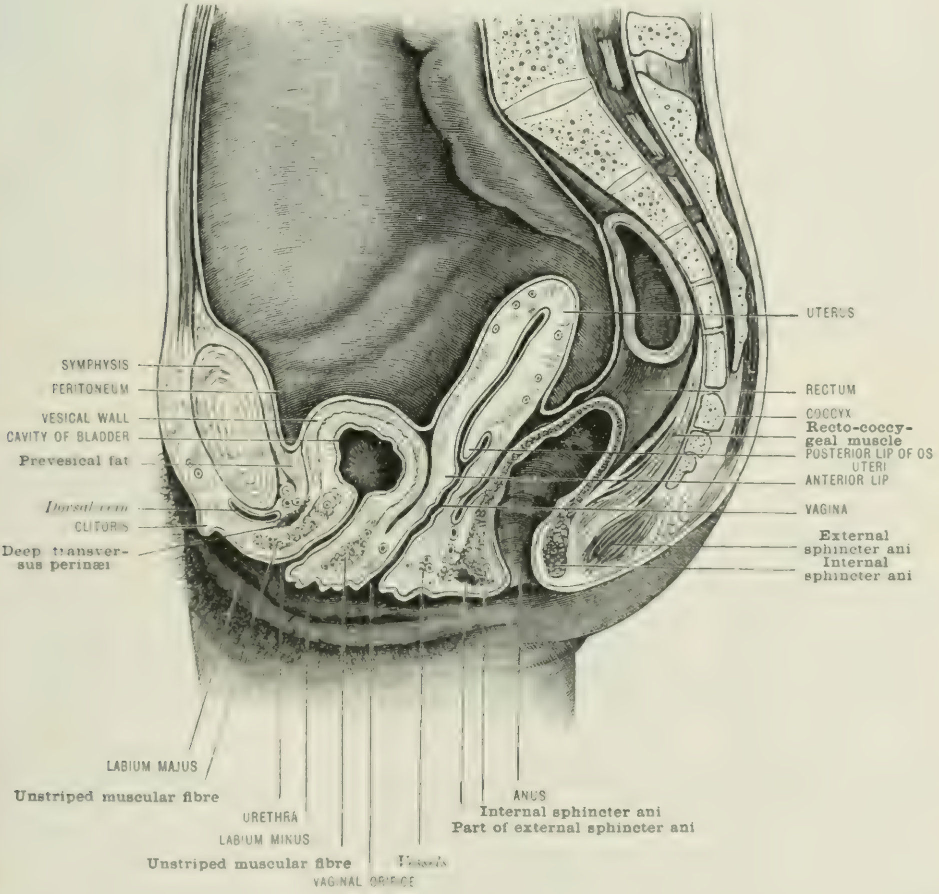
The **CLITORIS** appears as a diminutive penile appendage at the upper part of the vulva, and is embraced by a kind of prepuce formed by the union of the two labia minora. It is composed of two corpora cavernosa which differ from the corresponding masculine structures only in their size and in their union distally into a rounded imperforate extremity, the **glans clitoridis,** covered by a layer of integument. The crura are supported dorsally by a suspensory ligament, and are attached to the ischial rami in the same manner as in the male.

The clitoris is relatively smaller in the adult than in the child, and is almost always concealed within the rima pudendi. It is a highly sensitive organ, and is capable of erection.

The **bulbi vestibuli** are two erectile bodies of somewhat pyriform shape, lying one on either side of the vestibule beneath the mucous membrane. The larger extremity of each is posterior and extends backwards nearly to the posterior commissure, touching the gland of Bartholin. The narrow anterior extremity, the **pars intermedialis** of Köbelt, runs forwards to meet its fellow of the opposite side beneath the clitoris. Superiorly, it is fixed to the superficial triangular ligament of the perinæum, while it is in relation internally to the urethral and vaginal orifices, and externally is invested by the fibres of the bulbo-cavernosus. It consists of erectile tissue, enveloped by a thin tunica albuginea. During the condition of engorgement it helps to narrow the vestibular portion of the vulva and the entrance of the vagina.

The **vessels** and **nerves** of the clitoris and bulbi vestibuli are the same as those of the analogous parts of the male.

FIG. 633.—SECTION OF THE FEMALE PELVIS. (After Henle.)


UTERUS
SYMPHYSIS
PERITONEUM
VESICAL WALL
CAVITY OF BLADDER
Prevesical fat
Dorsal vein
CLITORIS
Deep transversus perinæi
RECTUM
COCCYX
Recto-coccygeal muscle
POSTERIOR LIP OF OS UTERI
ANTERIOR LIP
VAGINA
External sphincter ani
Internal sphincter ani
LABIUM MAJUS
Unstriped muscular fibre
URETHRA
LABIUM MINUS
Unstriped muscular fibre
Vessels
VAGINAL ORIFICE
ANUS
Internal sphincter ani
Part of external sphincter ani

The **muscles** appended to the erectile structures again are very similar to those described in connection with the penis. The **ischio-cavernosi** are identical in attachments with the erectores penis; but the **bulbo-cavernosi** are separated in the middle line by the vulvar fissure, and appear on each side as a delicate, and sometimes very indistinct, plane of muscular fibres, called the **constrictor vaginæ**, attached behind to the tendinous centre of the perinæum, and breaking up in front into tendinous slips which run in close external relation to the bulbi vestibuli, and become lost above and below the clitoris. Their function is to compress the bulbs and to constrict the vestibule and vaginal orifice. The **transversi perinæi** have the same connections as in the male.

THE URETHRA (figs. 633, 634).—The female urethra represents only the upper part of the male canal, and is similarly related to the superior and inferior triangular ligaments. It is about an inch and a half (37 mm.) in length, and is directed upwards and slightly backwards to open into the bladder about an inch (25 mm.) behind the middle of the symphysis. Its posterior wall is in contact with the vagina, and it is surrounded in front and at the sides by a plexus of veins (**plexus of Santorini**). The posterior margin of the meatus usually presents a tubercular prominence by which the position of the orifice may be distinguished during catheterism.

As in the male urethra, the narrowest portion of the canal is the external meatus, but the whole tube is sufficiently dilatable in most cases to allow the careful introduction of the finger while the patient is under an anaesthetic. A case is recorded by William Cowper (1697) in which, as a result of an imperforate condition of the hymen, it became the channel of sexual congress.

Structurally it consists of a highly elastic mucous membrane and a strong muscular coat. The **mucosa** is lined with three or four layers of epithelial cells, the more superficial of which are prismatic in form, and presents a few lacunæ and some rudimentary glandular follicles. The muscular coat is divisible into external circular and internal longitudinal layers, both intermingled with fibres of elastic tissue and with large venous plexuses which may undergo varicose dilatation near the external orifice and form a pile-like tumour. The circular fibres are very strongly developed at the vesical end of the canal and constitute a powerful sphincter; these are surrounded by a quantity of striped and unstriped fibres which form an incomplete ring, deficient only in its posterior or vaginal segment, and probably represent the prostatic fibres and the deep transversus perinæi of the male. It is surrounded by a muscular sphincter composed of striped and unstriped fibre corresponding to the deep transversus perinæi in the male, and partly, perhaps, to the musculature of the prostate.

THE VAGINA

The **vagina** is a passage which extends upwards and slightly backwards from its external opening at the vestibule, and terminates above by embracing the neck of the uterus. Its vulvar aperture is guarded in the virgin by a fold of mucous membrane called the **hymen.**

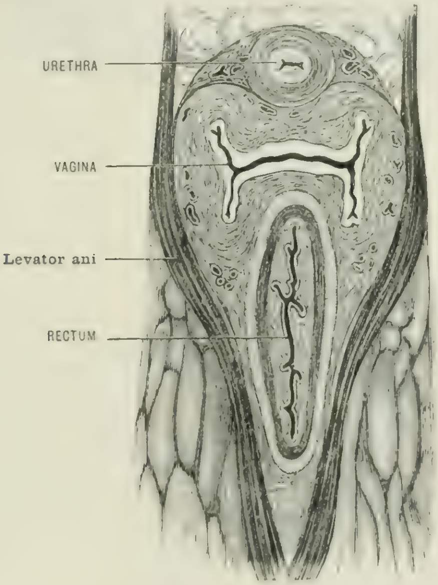
Form and direction (figs. 633, 634).—In its ordinary condition the vaginal canal is represented by a fissure which in horizontal section assumes the form of the letter **H**, with a transverse limb about an inch in length and two short vertical limbs (fig. 633). In longitudinal section (fig. 633) the fissure branches above, a short limb (occasionally ill-marked or absent) passing in front of the anterior lip of the os uteri, a much longer limb extending behind the os to end about three-quarters of an inch above the extremity of the posterior lip. The angle of reflexion of the vaginal on to the uterine mucous membrane is called the **fornix.** The direction of the passage is upwards and backwards, forming an angle of about 30° with the long axis of the body, and usually presenting a slight posterior concavity adapted to the convexity of the rectal ampulla; the course and direction, however, vary with the degree of pelvic inclination peculiar to the individual, and to some extent with the condition of the bladder and rectum.

The two walls are of very unequal length, the anterior measuring about two inches and three-quarters (7 cm.), while the posterior is prolonged upwards nearly an inch (9.5 cm.) further.

Relations.—Anteriorly, it is opposed to the urethra and posterior wall of the bladder. It is intimately united with the lower two-thirds of the urethra, but is separated from the upper third and from the bladder by loose connective tissue continuous with the subperitoneal fascia. The canal as a whole is narrowest below, and gradually increases as it ascends, reaching its greatest admeasurement where it surrounds the os uteri. Its dilatability is enormous, as may be inferred from the passage of the fœtus in parturition. The ureters pierce the vesical wall in front of the vagina an inch and a quarter below the level of the os uteri. **Posteriorly,** it is in relation with the rectum, but is separated from it above for about three-quarters of an inch (18 mm.) by the peritoneal *cul-de-sac* called the **pouch of Douglas,** in the middle by subperitoneal connective tissue, and below by the tissues of the perinæal body. In the latter situation the two canals diverge, and the perinæal body hence appears on sagittal section as a triangle the base of which is formed by the integument. **Laterally,** it is in contact with the vaginal branch of the uterine artery, and a venous plexus lying in the subperitoneal tissue at the base of the broad ligaments. It is crossed obliquely in its upper third by the ureters, and in its lower two-thirds by the anterior borders of the levatores ani. The finger passed within the passage and pressed to either side may be made to feel the resistance of the pelvic wall, and to distinguish the presence or absence of morbid growths or effusions. The **duct of Gärtner,** a relic of the Wolffian duct, may occasionally be found by the side of the upper half of the vagina as a minute tube or fibrous cord. Two orifices which open into the vagina near the meatus, sometimes called Skene's tubes, are regarded by some morphologists as the terminations of Gärtner's ducts.

The lower end of the vagina pierces the triangular ligament, and it is here that the resistance to dilatation is greatest. The inlet may be temporarily narrowed by the engorgement of the bulbi vestibuli, or by the action of the constrictor vaginæ, and perhaps also by that of the levatores ani.

FIG. 634.—HORIZONTAL SECTION OF VAGINA AND ADJACENT STRUCTURES. (After Henle.)



The **mucous surface** of the lower half or two-thirds of the vagina presents on the anterior wall a median longitudinal ridge or **carina,** and on the posterior wall two ridges, the **columnæ rugarum,** from all of which pass a number of transverse **rugæ.** These markings diminish in distinctness with advance in age and with successive parturitions. The membrane is of a pale rose colour in periods of quiescence, but becomes turgid during the catamenial period, and in pregnancy.

The **hymen** has been a subject of much speculation amongst the learned and unlearned of all ages. Its very existence was at one time denied by many great authorities, and the significance to be attached to its presence or absence is still a question in medical jurisprudence. It appears in the virgin as an imperfect septum pierced by an irregular aperture which usually reaches to the anterior vaginal wall, and leaves a fold of semilunar form behind; but it may be represented by a circular curtain pierced by one, two, or more apertures. It varies greatly in strength and elasticity, and although it is nearly always ruptured by the first act of sexual congress, it may remain unbroken until parturition. An imperforate condition of the membrane is occasionally present, and may necessitate a surgical operation at the commencement of the menstrual period.

Structure.—The vaginal wall is composed of three coats, fibrous, muscular, and mucous, and has a thickness of one-eighth to one-sixth of an inch. The outer **fibrous** coat is derived from the recto-vesical fascia, and holds in its meshes a plexus of veins. The **muscular** coat comprises two layers of strong unstriped fibres, the outer longitudinal, continuous above with the uterine muscle and with the utero-sacral ligaments; and the inner circular and more largely developed near the vulvar aperture.

The **mucous membrane** is highly elastic, beset with papillæ and covered with a squamous laminated epithelium continuous with that of the os uteri and vulva. It has no glands, and hence the fluid which moistens it is rather of the nature of a transudation than of a secretion.

Vessels and Nerves.—The **arteries** are derived from an inferior branch of the uterine and from the internal iliac, communicating below with branches of the external pudic; they run along the lateral aspect of the passage and give twigs to the anterior and posterior surfaces. The **veins,** similarly disposed, form a rich network in the muscular and mucous coats, and terminate in the vaginal and uterine trunks. The **lymphatics,** arranged in two intercommunicating networks, mucous and muscular, from numerous trunks which accompany the veins and terminate in the pelvic glands, a few from the neighbourhood of the vestibule, however, reaching the inguinal glands. A small gland is occasionally found between the rectum and vagina.

The **Nerves** come from the hypogastric plexus, the fourth sacral, and the pudic.

THE UTERUS

The **uterus,** or **womb** (figs. 635–638), is a hollow muscular organ lined with mucous membrane. It communicates above with the two Fallopian tubes, and below with the vagina, and lies within the pelvic cavity between the bladder and rectum, fixed in its place by folds of peritoneum and certain bands of unstriped muscle. It varies greatly in size and form at different periods of life and under different physiological conditions.

The adult uterus is flattened from before backwards, pyriform in its outlines when seen from the front, and is divided into two main portions, body and cervix, by a transverse constriction, the isthmus. The **isthmus** may be regarded as the weak point in the organ, and it is here that the various pathological flexions take place. Its position in the virgin uterus is about midway between the two extremities, but it lies near the junction of the middle and lower thirds in women who have borne children.

The upper portion, or **body,** presents two surfaces, three borders, and two angles. The **anterior surface** is almost flat, and is covered by a layer of peritoneum which is reflected at the level of the isthmus upon the bladder, forming a shallow utero-vesical pouch which is occupied by coils of small intestine. The **posterior surface** is distinctly convex, and covered in its whole extent by a layer of peritoneum which is prolonged downwards over the neck and for a short distance upon the posterior wall of the vagina before undergoing reflexion upon the rectum to form the **recto-vaginal pouch,** or **pouch of Douglas.** The **superior border,** or base, is thick and rounded, and is covered by the peritoneum, which passes from the anterior to the posterior surface. The **lateral borders,** slightly convex and running downwards and inwards, correspond to the line of attachment of the peritoneal folds called the **broad ligaments.** The **superior angles,** at the junction of the superior with the lateral borders, give attachment to the oviducts or Fallopian tubes. The term **fundus** is loosely applied to the upper part of the body.

The **cervix** is cylindrical in section, wider in the middle than above or below, and may be divided into three portions,—an upper **supravaginal zone,** a middle **zone of vaginal attachment,** and a lower **intravaginal zone,** the **os uteri.** The **supravaginal zone,** representing about one-half of the neck behind and two-thirds in front, is in relation anteriorly with the bladder; posteriorly it is covered with the peritoneum of the anterior wall of the pouch of Douglas, and at the sides it is connected with the broad ligament, in which lie the uterine vessels and the ureter, the latter at a distance of a little over half an inch. The **zone of vaginal attachment** is obliquely set, extending higher behind than in front, and has a depth of about one-fifth of an inch (5 mm.). The **intravaginal zone**, or **os uteri**, is covered with mucous membrane continuous with that of the vagina. It presents the external aperture of the uterine cavity, usually in the form of a transverse fis-

FIG. 635.—THE FEMALE ORGANS OF GENERATION. (Modified from Sappey.)

(Vagina divided and laid open behind.)

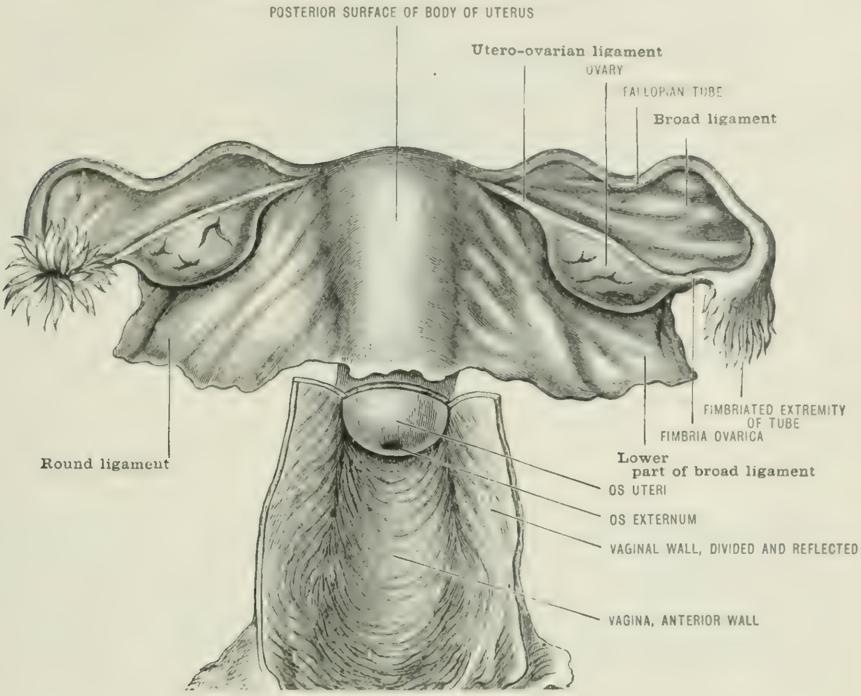
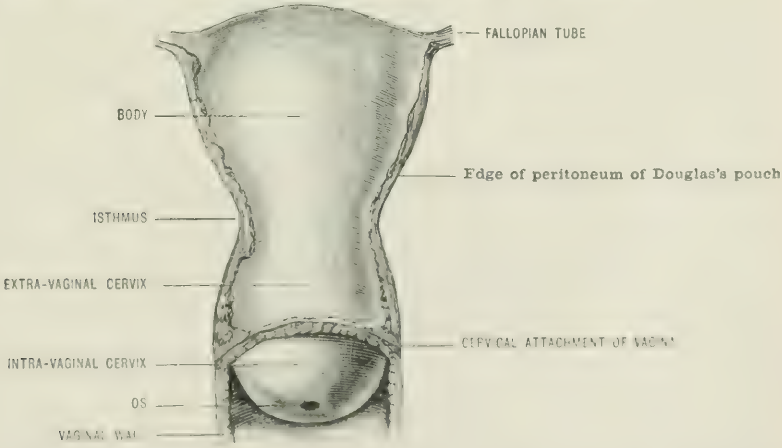

POSTERIOR SURFACE OF BODY OF UTERUS
Utero-ovarian ligament
OVARY
FALLOPIAN TUBE
Broad ligament
Round ligament
FIMBRIATED EXTREMITY OF TUBE
FIMBRIA OVARICA
Lower part of broad ligament
OS UTERI
OS EXTERNUM
VAGINAL WALL, DIVIDED AND REFLECTED
VAGINA, ANTERIOR WALL

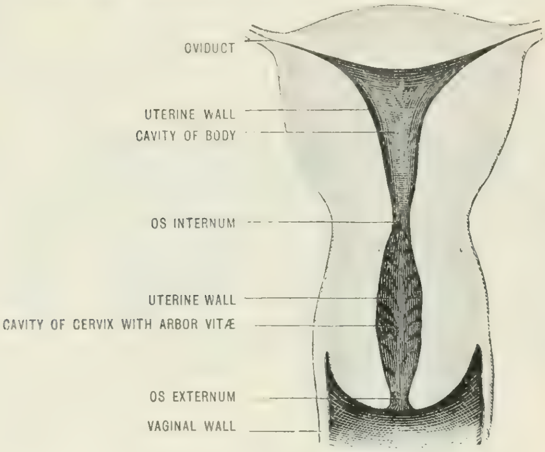
FIG. 636.—THE POSTERIOR SURFACE OF THE UTERUS. (After Sappey.)


FALLOPIAN TUBE
BODY
Edge of peritoneum of Douglas's pouch
ISTHMUS
EXTRA-VAGINAL CERVIX
CERVICAL ATTACHMENT OF VAGINA
INTRA-VAGINAL CERVIX
OS
VAGINAL WALL

sure, about a quarter of an inch (6 mm.) in length, bounded by two prominent **labia,** anterior and posterior, both of which are in contact with the posterior wall of the vagina. The anterior lip is the thicker, the shorter, and the lower; the posterior lip is longer on account of the greater height of the posterior vaginal fornix. After childbirth the labia usually become notched and irregular.

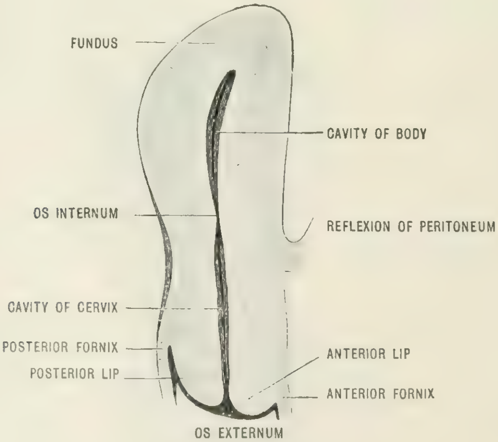
Dimensions.—The size of the uterus varies within wide limits. Its average length in the nulliparous adult is about two and a half inches (6 cm.) and its greatest breadth about an inch and a half (4 cm), but in women who have borne children these dimensions are about one-fifth greater. Its weight averages seven drachms in nulliparæ, nine to twelve drachms in multiparæ.

FIG. 637.—FRONTAL SECTION OF THE VIRGIN UTERUS. (After Sappey.)


OVIDUCT
UTERINE WALL
CAVITY OF BODY
OS INTERNUM
UTERINE WALL
CAVITY OF CERVIX WITH ARBOR VITÆ
OS EXTERNUM
VAGINAL WALL

Direction.—The direction of the uterine axis is undoubtedly variable, and it is probable that observations made after death are open to misinterpretation. It appears to coincide under ordinary circumstances with the long axis of the body, both in the recumbent and erect postures, but may be inclined forwards to the extent of 15° or 20° when the bladder is empty, or may be deflected to the right when the rectum is full, and is furthermore affected by the condition of the neighbouring intestinal coils.

FIG. 638.—SAGITTAL SECTION OF THE VIRGIN UTERUS. (After Sappey.)


FUNDUS
CAVITY OF BODY
OS INTERNUM
REFLEXION OF PERITONEUM
CAVITY OF CERVIX
POSTERIOR FORNIX
POSTERIOR LIP
ANTERIOR LIP
ANTERIOR FORNIX
OS EXTERNUM

Variations in form according to age.—In young children the body is but slightly developed in proportion to the cervix, and the prominence of the intravaginal segment is relatively great. In the virgin uterus of a young adult the length is about equally divided between body and cervix, but after childbirth the body never returns to its original size, and its length when involution is complete is nearly double that of the neck. In old age the entire organ undergoes atrophy.

The **cavity** of the uterus is reduced to a fissure by the antero-posterior flattening of the walls. It is divisible into two segments, that of the body and that of the neck. The shape of the **cavity of the body** is that of a triangle with convex sides (in the virgin) and three open angles. At the two superior angles are the orifices of the oviducts, and the lower angle presents the os uteri internum or aperture of communication with the neck. The walls are smooth, and moistened with mucus.

The average length of the cavity in the nulliparous adult is about two inches (5 cm.); in multiparæ, two and a quarter to two and a half inches (5·5 to 6 cm.). The greatest transverse diameter is a little less than half of these measurements.

The **cavity of the neck** is fusiform, terminating in the **os internum** above, and in the **os externum** below. The superior opening is circular, the inferior usually in the form of a transverse fissure. The mucous lining of the anterior and posterior walls presents ridges which bear some resemblance to those of the vagina, but are dependent upon the arrangement of the innermost layers of the muscular wall, and not upon a simple plication of the mucous membrane. The whole length of each wall is traversed by a longitudinal nearly median ridge or stem, from which pass a number of branches in an outward and slightly upward direction. The figure formed by these folds is designated by the name of *arbor vitæ uterina*; it is most marked in the young, and tends to effacement after repeated parturitions. The cavity usually contains a plug of alkaline mucus.

Structure.—The uterus is composed of three coats—an outer sero-fibrous, a middle muscular, and an inner mucous. The **serous membrane** covers the upper half or two-thirds of the anterior surface, the whole of the supravaginal portion of the posterior surface, and the summit. The lower portion of the anterior wall is separated from the bladder by cellular tissue continuous with the subperitoneal fascia, and a thin layer of the same structure may be demonstrated over the lower part of the posterior surface and laterally into the base of the broad ligament on either side between the two peritoneal laminæ. Owing to this disposition of the subserous tissue, the whole of the cervix uteri may be amputated without encroaching upon the peritoneal cavity.

The **muscular coat** constitutes the greater part of the thickness of the organ. The arrangement of the fibres is very complex, but a fairly satisfactory division into three layers may be demonstrated:—a thin **outer** layer, partly longitudinal, partly transverse in direction, continuous with the muscular fibres of the oviducts, vagina, round, ovarian, and utero-sacral ligaments, and with the muscular expansion in the broad ligaments; a **middle layer,** very thick, its fibres plexiform, running in all directions, and intermingled with large venous plexuses in the body of the uterus, the innermost strands forming sphincteric rings around the os internum and around the orifices of the oviducts; and a thin **internal layer,** longitudinal in the body, and producing the ridges of the arbor vitæ in the cervix.

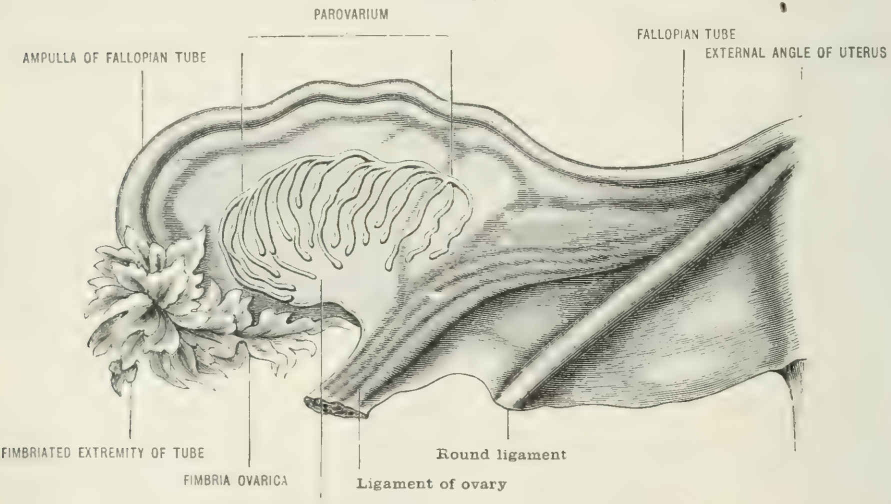
The **mucous membrane** of the *body* is smooth and pale, lined with cylindrical ciliated epithelium, and pierced by innumerable tubular glands. The ciliary motion is from within outwards. The mucous membrane of the cavity of the *neck* is thicker and is plicated in the manner already described; its epithelium is ciliated down to the external opening, but there undergoes a transition into the squamous laminated epithelium which covers the intravaginal portion of the os. Many tubular and racemose mucous glands open into the furrows of the arbor vitæ, and these are liable to pathological changes which cause them to assume a vesicular character, when they are sometimes known under the fanciful name of **ovula Nabothi.**

Ligaments.—The so-called ligaments of the uterus are of two kinds, peritoneal and muscular.

The **peritoneal ligaments** are six in number: two lateral, two anterior, and two posterior.

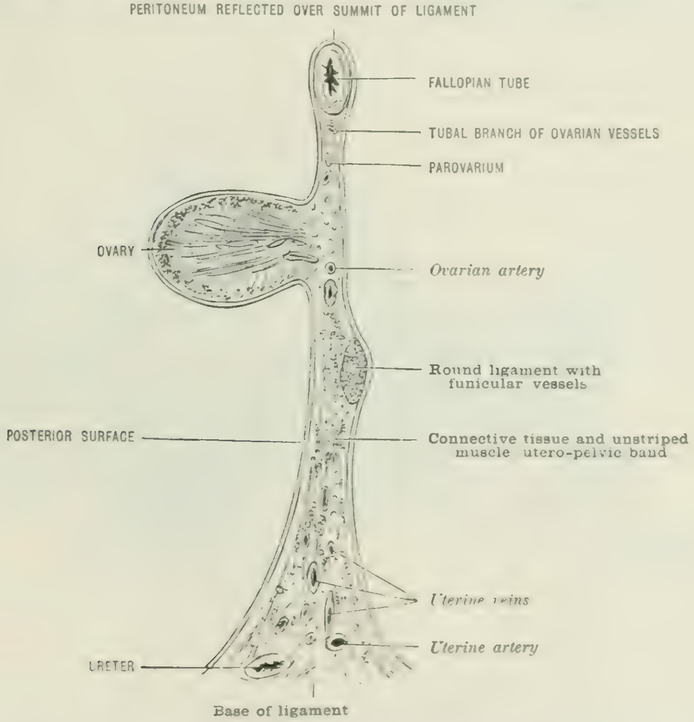
The **lateral** or **broad ligaments** (fig. 639), called also **alæ vespertilionis** from their fancied resemblance to the wings of a bat, are formed by a duplicature of peritoneum extending from the sides of the uterus and vagina transversely outwards to the sides of the pelvis. The two layers of peritoneum are continuous above and form the free border of the fold, but diverge laterally and below, where they pass on to adjacent structures. Each ligament presents two surfaces and four borders. The **superior** or **free border** is represented by the summit of the plication, which turns around the oviduct and follows a sinuous course towards the side of the pelvis, its outermost extremity lying external to the fimbriated extremity of the Fallopian tube and forming a sharp fold, the **ligamentum infundibulo-pelvicum,** which conveys the ovarian vessels. The **internal border** is attached to the sides of the uterus and vagina, the two laminæ separating to transmit the utero-vaginal vessels, and muscular bands, which pass from the uterus into the peritoneal fold. The **inferior border** is attached to the levator ani and recto-vesical fascia; its laminæ are separated by fat-bearing cellular tissue (subperitoneal) which gives passage to vessels and nerves and to the ureter; and the anterior layer is much shorter than the posterior, owing to the higher level of its point of reflexion. The **external border** lies against the obturator fascia, and transmits the uterine vessels and the round ligament.

Fig. 639.—The Broad Ligament and its Contents, seen from the Front. (After Sappey.)



The **structures enclosed between the two layers of the broad ligament** are:—(1) The **ovary** and its **ligament,** the former projecting from the posterior lamina and invested by a modified epithelium; the latter, composed of unstriped muscular fibre, passing between the side of the uterus and the inner or lower extremity of the ovary. (2) The **Fallopian tube,** lying at the upper margin immediately beneath the point of continuity of the two laminæ; its outer fimbriated extremity turned backwards and inwards to the ovary, and attached by one of the fringes to the outer or lower end of the organ. It does not reach quite to the pelvic wall. (3) The **round ligament,** a muscular band running downwards and outwards, forming a ridge beneath the anterior lamina, and eventually passing to the internal inguinal ring and through the inguinal canal into the labium. (4) Fœtal relics: (*a*) the **epovarium,** or **epoöphoron,** a group of twelve to twenty effete tubules of the Wolffian body lying close to the attached border of the ovary, bearing a certain resemblance in plan to the vasa efferentia of the testicle, and joining a kind of collecting tube above. (*b*) The **duct of Gartner,** a canal representing the lower part of the Wolffian duct, is constant in certain animals (cow, etc.) as a tube running on each side of the uterus and vagina, and opening at the lower end of the latter passage. In the human subject it is sometimes found in the form of a small muscular cord, or epithelial canal, near the cervix uteri or upper part of the vagina. According to some anatomists, its lower end is occasionally found as a little tube opening into the side of the vulva near the urinary meatus, but it is doubtful whether the tube in question is more than a mucous duct. (*c*) The **parovarium, or paroophoron,** a few scattered, imperfectly developed tubules in the neighbourhood of the epoöphoron, also representing traces of the Wolffian body. They are usually seen as small whitish or yellowish grains in the infant, but are rarely demonstrable in the adult. (*d*) The **hydatid of Morgagni,** a long pediculated vesicle of the size of a millet seed or pea, occasionally dependent from the fimbriæ of the tubes, is believed to be a relic of the Wolffian body. (*e*) Small pedunculated cysts often found on the posterior layer of the broad ligament and derived from the parovarium. (5) The uterine, ovarian, and funicular vessels, anastomosing near the angle of the uterus; and the uterine plexus of nerves. (6) A quantity of loose adipose cellular tissue lying between the muscular and other structures and the serous membrane, and in continuity with the subperitoneal fascia of the pelvis. (7) Involuntary muscular fibres passing from the obturator fascia to become attached to the sides of the uterus and vagina, ensheathing the vessels and serving as a support to the uterus. They may be compared with the fibro-muscular subperitoneal bands supporting the third stage of the duodenum, the transverse colon and small intestines, and are essentially sustentacular in relation to the viscera and to their vessels and nerves.

FIG. 640.—DIAGRAMMATIC SECTION OF THE BROAD LIGAMENT.


PERITONEUM REFLECTED OVER SUMMIT OF LIGAMENT
FALLOPIAN TUBE
TUBAL BRANCH OF OVARIAN VESSELS
PAROVARIUM
OVARY
Ovarian artery
Round ligament with funicular vessels
POSTERIOR SURFACE
Connective tissue and unstriped muscle utero-pelvic band
Uterine veins
Uterine artery
URETER
Base of ligament

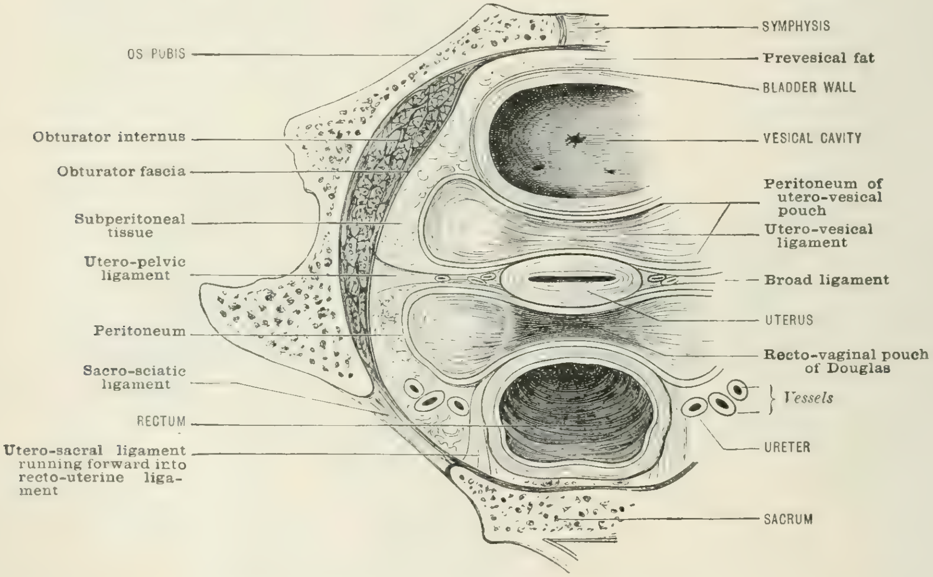
The **posterior peritoneal** or **recto-uterine ligaments** are two serous folds which run backwards from the intraperitoneal portion of the cervix uteri and vagina to become continuous with the peritoneal investment of the second stage of the rectum. They form the lateral boundaries of the pouch of Douglas, and between their layers lie muscular **utero-sacral ligaments,** comparable to the expansion in the broad ligaments, with loose connective tissue and a number of anastomosing branches of the uterine and hæmorrhoidal vessels.

The **anterior peritoneal** or **utero-vesical ligaments** are two ill-defined folds which pass one on each side from the cervix uteri to the bladder.

The **muscular ligaments** lying between the peritoneal folds are four pairs: three in the broad ligaments, the round or utero-inguinal, the utero-ovarian, and the utero-pelvic, and one in the posterior ligaments, the utero-sacral. They have already been briefly referred to.

The **round** or **utero-inguinal ligament** (fig. 639) is a cord, about five inches in length, attached to the uterus just below the Fallopian tube, and there continuous with the superficial uterine fibres. From this point it runs obliquely downwards, outwards, and forwards, immediately beneath the anterior layer of the broad ligament, to reach the pelvic wall; it then loops around the curve of the deep epigastric artery on the inner side of the external iliac artery, and enters the inguinal canal at the internal ring. In its course through the canal it is supplemented by a set of striped fibres, some derived from the muscular walls of the abdomen, others apparently of independent origin; and it may be accompanied by a tube of peritoneum, the **canal of Nuck,** which is constant in the fœtus and not infrequently persistent during childhood and even adult life. The ligament then gives off a few of its newly acquired striped fibres to the pillars of the ring and to the pubic spine, and, emerging from the external ring, finally breaks up into a number of delicate fasciculi which become lost amongst the interlobular connective tissue of the large pad of fat which occupies the labium majus.

FIG. 641.—SECTION OF THE PELVIS SHOWING THE LIGAMENTS OF THE UTERUS.


SYMPHYSIS
OS PUBIS
Prevesical fat
BLADDER WALL
Obturator internus
VESICAL CAVITY
Obturator fascia
Peritoneum of utero-vesical pouch
Subperitoneal tissue
Utero-vesical ligament
Utero-pelvic ligament
Broad ligament
UTERUS
Peritoneum
Recto-vaginal pouch of Douglas
Sacro-sciatic ligament
Vessels
RECTUM
Utero-sacral ligament running forward into recto-uterine ligament
URETER
SACRUM

In structure it is composed of unstriped muscle with areolar and elastic tissue, reinforced in the inguinal canal by striated muscular fibres and funicular vessels and nerves. The **funicular artery,** conveyed by the round ligament, is a branch of the superior vesical. It is accompanied by a plexus of veins, and anastomoses in the labium with branches of the external pudic, and at the superior angle of the uterus with the uterine and ovarian.

The **utero-sacral ligaments** (fig. 641) are flat muscular bands, extending from the highest part of the cervix uteri, where they are more or less continuous with the uterine fibres in the recto-uterine peritoneal folds, to the sides of the sacrum opposite the lower border of the sacro-iliac synchondroses. They run one on each side of the rectum near the junction of the first and second stages of this portion of the intestine, closely connected with its muscular coat, and more anteriorly are in lateral relation with the pouch of Douglas.

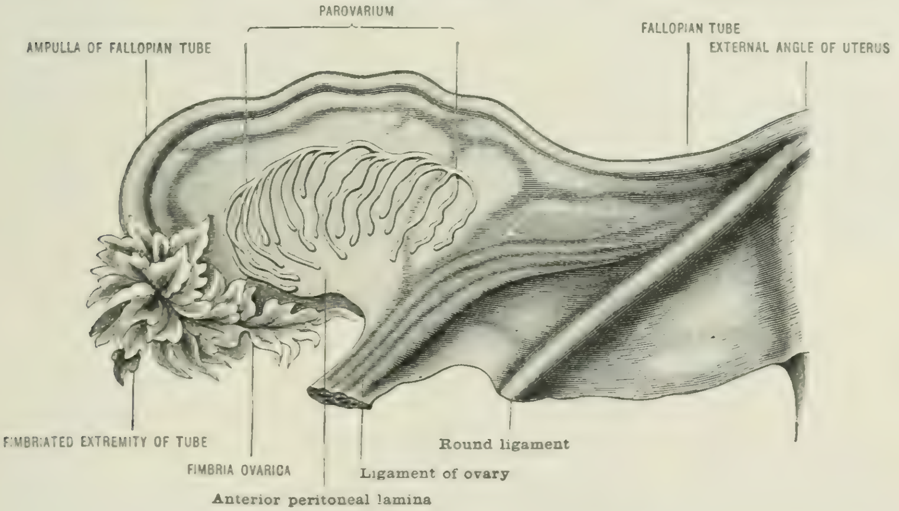
The **utero-pelvic ligaments** (fig. 641) are the expansions of muscular tissue already described in connection with the broad ligament. They radiate from the fascia over the obturator internus to the sides of the uterus and vagina, and ensheathe the utero-vaginal vessels and nerves.

The **utero-ovarian ligaments** (fig. 639), or **ligaments of the ovaries,** are short rounded cords continuous with the uterine fibres at the superior angle of the organ behind the Fallopian tube, and joining externally the inner end and attached border of each ovary. These various ligamentous structures all serve to maintain the normal position of the uterus. In addition, the utero-ovarian ligament aids in the fixation of the ovary, and the round and utero-pelvic ligaments form protective sheaths for vessels and nerves.

THE FALLOPIAN TUBES OR OVIDUCTS

The **Fallopian tubes** (fig. 639) represent the upper extremities of the Müllerian ducts, and may probably be regarded as cornua uteri both in structure and morphology. They are two trumpet-shaped tubes structurally continuous with the superior angles of the uterus, and running between the two layers of the broad ligaments to become closely connected with the ovaries, partly by direct attachment, partly by a peculiar contiguity. Each duct opens internally into the uterine cavity, and its external orifice establishes a continuity between the tubo-ovarian mucous membrane and the peritoneum, but under normal circumstances is closely applied to the surface of the ovary, and receives the ova which are detached from the gland, transmitting them to the uterine cavity. It is about four and a half inches (11 cm.) in length, straight, narrow, and somewhat cord-like at its uterine end for a distance of about an inch and a half; flexuous, and irregularly dilated in the rest of its length as far as its free extremity, where it becomes expanded into a trumpet-shaped mouth, fringed by a circle or circles of diverging villous processes or **fimbriæ,** one of which, the **fimbria ovarica,** or tubo-ovarian ligament, is attached to the outer extremity of the ovary. One or two little cystic pediculated appendages, like the hydatid of Morgagni in the testicle, may also be appended to the mouth. The aperture (**ostium abdominale**) in the middle of this expansion is very small, not more than half a line or a line in diameter, but its mucous membrane may be prolonged for some distance along a furrow in the tubo-ovarian ligament.

FIG. 642.—THE BROAD LIGAMENT AND ITS CONTENTS, SEEN FROM THE FRONT. (After Sappey.)



The narrow extremity, or **isthmus,** has a diameter of about an eighth of an inch

(3 mm.), the dilated portion or **ampulla** measures about a third of an inch (8 mm.), and the terminal expansion exclusive of its fringes has a width of about a quarter to a third of an inch, the free fimbriæ ranging in length from two-fifths to three-fifths (10 to 15 mm.) of an inch, while the fimbria ovarica attains an inch or even two inches (2·5 to 5 cm.). Accessory fimbriated extremities are occasionally met with.

The **direction** of the oviduct traced from its uterine attachment is transversely outwards as far as the middle of the ovary; beyond this point the tube winds in a flexuous course backwards and inwards around the gland in the manner described below.

Structure.—The tube has four coats—serous, cellular, muscular, and mucous. The **serous coat,** represented by the fold at the free border of the broad ligament, is incomplete, like that of the small intestine, the muscular tunic being uncovered by peritoneum for about one-fourth or one-fifth of its circumference along the line of attachment of the two serous laminæ, and hence a rupture of the duct may lead to an escape of its contents either into the peritoneal cavity or into the interserous space. The **cellular coat** is a kind of adventitia, rich in vessels, and continuous with the subperitoneal tissue of the broad ligament. The **muscular coat,** about the sixtieth of an inch in thickness, consists of circular and longitudinal fibres; the latter for the most part sparingly distributed outside the former, but near the outer extremity of the tube appearing also as an innermost layer. The circular layer is most attenuated near the fimbriated extremity. The **mucous membrane** is characterised mainly by its plications. The folds are longitudinal in direction, and relatively simple in the isthmus, where the cavity appears as a stellate fissure when cut across; but in the ampulla the multiplication of surface is very complex, and in a transverse section presents a deceptive appearance of branching tubular glands within the depth of a thick mucosa. At the fimbriated extremity of the tube, the plications are continued on to the fringes. The epithelium is cylindrical and ciliated, the motion being towards the uterus. At the trumpet-shaped extremity it passes by transition into the pavement epithelium of the serous membrane. The subepithelial tissue contains a longitudinal *muscularis mucosæ.*

THE OVARIES

The **ovary** (fig. 635) is a paired organ which projects strongly from the posterior surface of the broad ligament. Its longest diameter averages an inch and a half, its greatest breadth about three-quarters of an inch, its thickness about half an inch; and its weight is ordinarily about 100 grains. The right is usually a little larger than the left.

Form, position, etc.—The typical shape resembles that of a broad almond. In anatomical preparations it appears as a horizontal appendage to the back of the broad ligament with an anterior attached border, a posterior free border, superior and inferior surfaces, an inner extremity connected with the utero-ovarian ligament, and an outer extremity receiving the fimbria ovarica of the Fallopian tube: it is most probable however that the position is different when the organs are *in situ* under normal circumstances. Symington in his examination of frozen sections in children found the ovary lying in a sagittal plane against the side wall of the pelvis with its long axis nearly vertical, so that its surfaces were internal and external, its borders anterior and posterior, and its extremities upper and lower, while the Fallopian tube ran upwards along the anterior attached border of the gland, then arching backwards above its upper extremity to end in the fimbriæ; and where the fimbriæ are fully developed they may embrace the posterior free border, and thus the tube is wound almost completely around the gland, leaving only the lateral surfaces exposed. The external surface is said to lie against the pelvic wall in a hollow between the internal iliac artery and vein, but there is every reason to believe that it is very variable in the adult. The laxity of its connections, the liability to changes of position during pregnancy, and the changing relations of the contiguous viscera make it difficult to accept any one of the many views as absolutely correct. The organ when enlarged may be felt through the vagina, and, better, through the rectum, and its position with regard to the surface is indicated by a point about two inches to the inner side of the anterior superior spine of the ilium. The surfaces and free border are of a dull white, and after puberty are scarred by breaches of surfaces due to the dehiscence of ripe ova; the attached border is pierced by the ovarian vessels and nerves which lie between the layers of the broad ligament, and their point of entrance is termed the **hilum.**

Structure.—The ovary consists of a parenchyma and a kind of capsule, or **tunica albuginea.** The latter, unlike the tunica albuginea of the testis, is a modification of the stroma of the gland, and does not exceed the two-hundred-and-fiftieth of an inch in thickness; it is crowned with an epithelium (columnar) differing in character from that of the serous membrane with which it is connected. The true gland-structure is a mass of connective tissue and unstriped muscle with vessels and nerves. It is very vascular in the neighbourhood of the hilum, where the veins are peculiarly large and closely set, and is condensed into a kind of cortex beneath the albuginea. The cortex is about half a line in thickness, and consists of interlacing bundles of white fibrous tissue, which pass insensibly into the faintly fibrillated tunica albuginea, and enclose multitudes of small vessels called **ovisacs,** or **Graafian follicles,** in which the ova are developed.

The majority of the ovisacs are microscopic, but as they ripen and approach the surface they increase in dimensions, and may even attain the size of a large white currant. Their rupture leads to the scarring already mentioned, and the empty capsule slowly disappears when impregnation has not occurred; but under the influence of the vascularisation of the organs during pregnancy, it may undergo a remarkable development and form a yellow plicated body known as the **corpus luteum.**

VESSELS AND NERVES OF THE UTERUS AND ITS APPENDAGES

The vessels are the uterine, ovarian, and funicular, all of which are paired. The **uterine artery** (fig. 643), a branch of the internal iliac, runs from its origin in a downward direction along the pelvic wall as far as the base of the broad ligament; then, crossing horizontally towards the cervix uteri in front of the ureter, it gives off some small vaginal and vesical branches, and runs upwards in a serpentine course close to the side of the body of the uterus, supplying transverse branches to the anterior and posterior walls of the organ. These anastomose with their fellows across the middle line, one larger branch opposite the junction of the body and cervix, forming with the corresponding vessel of the other side, the 'arterial circle of Huguier.' Finally they communicate at the upper angle with the terminal twigs of the ovarian and funicular arteries. The **uterine veins** are of very large size, and on leaving the uterus form a plexus in the muscular tissue of the broad ligaments, at length joining a trunk which runs side by side with the artery to end in the internal iliac vein.

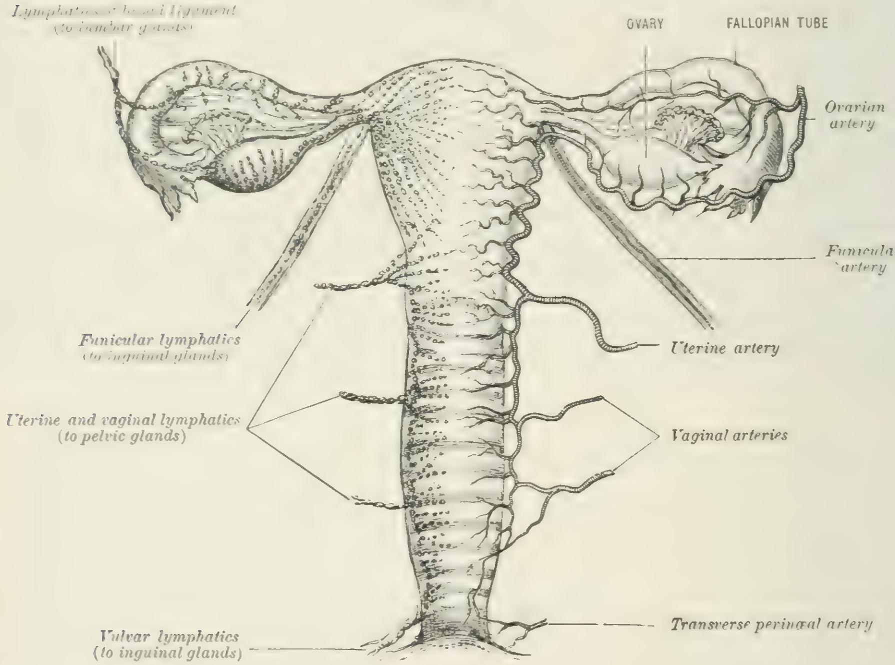
The **ovarian artery,** arising from the aorta (like the spermatic in the male), crosses the common iliac artery, and is conducted into the broad ligament by the ligamentum infundibulo-pelvicum (page 1048), which extends to the outer end of the oviduct. It breaks up into two divisions: (1) The *tubal*, which runs along the lower border of the oviduct, where the peritoneal layers of the tube separate, and sends numerous branches to it; and (2) the *ovarian proper*, a large serpentine vessel which gives off many large branches into the hilum of the gland, and then passes to the angle of the uterus, where it ends by anastomosing with the uterine and funicular arteries.

The **ovarian veins,** very largely developed about the hilum of the ovary, appear as a plexus in the broad ligament, and, reaching the margin of the plexus, assume a pampiniform arrangement around the artery. The right ends in the vena cava, the left in the renal vein.

The **funicular artery** is an offset of the vesical. It joins the round ligament at the internal ring, and divides into ascending and descending branches, the former running backwards in the substance of the ligament as far as the angle of the uterus, where it communicates with the ovarian and uterine; the latter passing with the ligament through the inguinal canal into the labium, there anastomosing with the external pudic. It is accompanied by its vein.

The **lymphatics** (fig. 643) of the uterus and Fallopian tubes form plexuses in the mucous membrane, in the muscular walls, and beneath the peritoneum. Those of the ovary originate in the perifollicular tissue around the Graafian vesicles, and escape at the hilum. The efferent vessels from these three organs may be divided into three groups with intercommunicating territories. (1) The first, including those of the body of the uterus, those of the ovary, and those of the Fallopian tube, unite by the side of the ovarian vessels and run with the veins to terminate in the prevertebral glands in front of the aorta and vena cava; (2) the second, those of the cervix uteri, form two trunks which run along the base of the broad ligament with the uterine vein to end in the pelvic glands which lie beneath the bifurcation of the iliac artery; (3) the third, those of the round ligament, follow this structure and end in the inguinal or lower iliac glands. Here as elsewhere the lymphatics are collateral with the veins.

FIG. 643.—DIAGRAM OF THE ARTERIES AND LYMPHATICS OF THE FEMALE GENERATIVE ORGANS.

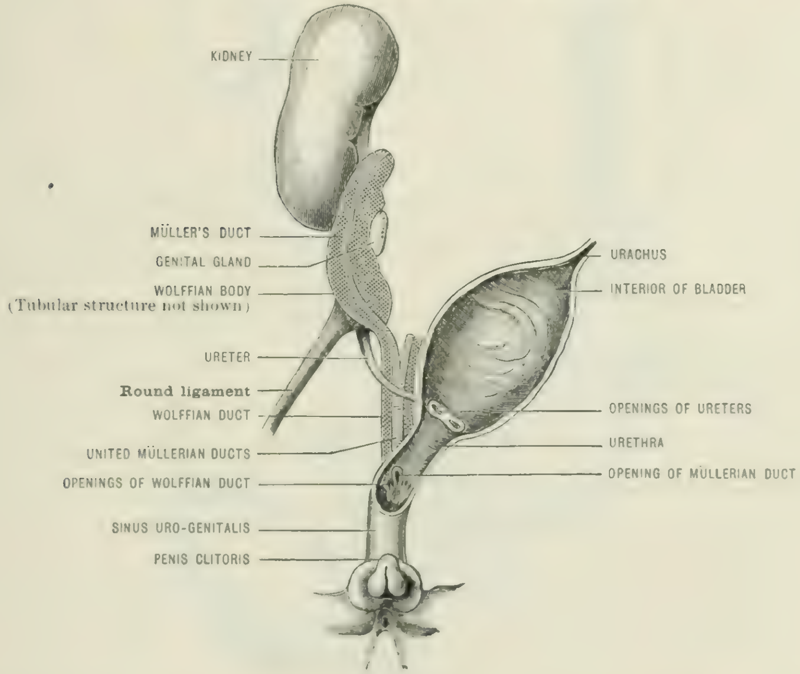

Lymphatics of broad ligament
(to lumbar glands)
OVARY
FALLOPIAN TUBE
Ovarian artery
Funicular artery
Funicular lymphatics
(to inguinal glands)
Uterine artery
Uterine and vaginal lymphatics
(to pelvic glands)
Vaginal arteries
Transverse perinæal artery
Vulvar lymphatics
(to inguinal glands)

The **nerves** of the uterus are derived from the third and fourth sacral, the hypogastric plexus of the sympathetic, and from the renal plexus, which also supplies the ovaries and oviduct.

DEVELOPMENT OF THE GENITO-URINARY ORGANS

There is at first a period in the growth of the embryo during which there is no indication of any provision either for the generative or for the urinary function. A little later the rudiments of a genito-urinary apparatus are laid down, but there is as yet no appearance of sexual differentiation. Finally, a third stage in the formative process is occupied by the evolution of the organs characteristic of the masculine or feminine type, and the completion of the glandular and other structures, which provide for the secretion, storage, and ultimate expulsion of the urine from the body. It will be seen that in the course of these developmental changes certain of the structures concerned appear and assume their permanent characters gradually and without alteration of plan; others, originally employed for purposes unconnected with the genito-urinary system, become adapted to take their place in this section of the economy; others belonging to the system from the first are brought into a special condition of functional activity only to undergo conversion to a different use later on; while others again may, according to the sex assumed by the fœtus, either dwindle into useless relics without ever taking any share in the work of the body, or may become elaborated into important and efficient parts of the reproductive organism.

FIG. 644.—DIAGRAM OF THE PRIMITIVE GENITO-URINARY ORGANS BEFORE DIFFERENTIATION OF SEX. (After Henle.)



The earliest appearance is that of a tube called the **Wolffian duct**, which opens by its hinder extremity into a **cloaca** or common outlet for the intestinal and urinary passages. From the fore part of this duct is developed a temporary organ, the **pronephros**, or **head-kidney**, in the form of vascular glomeruli. Behind this soon appear a number of tubes, which open at right angles into the mid portion of the duct, and constitute the **mesonephros, mid-kidney**, or **Wolffian body**. Still farther back, from the posterior end of the duct, springs the **metanephros**, or **hind-kidney**, a mesoblastic growth around a hollow branching protrusion from the duct, with which tubules and glomeruli subsequently become connected. The pronephros quickly disappears in the higher vertebrates; the mesonephros, which reaches its maximum development by the sixth week, soon ceases to discharge its renal function, and either becomes a useless relic in the broad ligament of the female pelvis, or undergoes transformation into an essential part of the male generative apparatus; while the metanephros becomes developed into the permanent kidney. The ureter and uriniferous tubules probably originate as special outgrowths from the posterior part of the Wolffian duct. The morphology of the suprarenal body is somewhat doubtful, but it is probable that the medulla is a derivative of the sympathetic system, and hence of epiblastic origin; while the cortex is a mesoblastic development in connection with the fore end of the Wolffian duct. It is at first larger than the kidney, but the latter attains an equal bulk by the tenth week, and then continues to increase, becoming considerably the greater by the end of fœtal life; but even at birth the suprarenal bodies are proportionally much larger than in the adult.

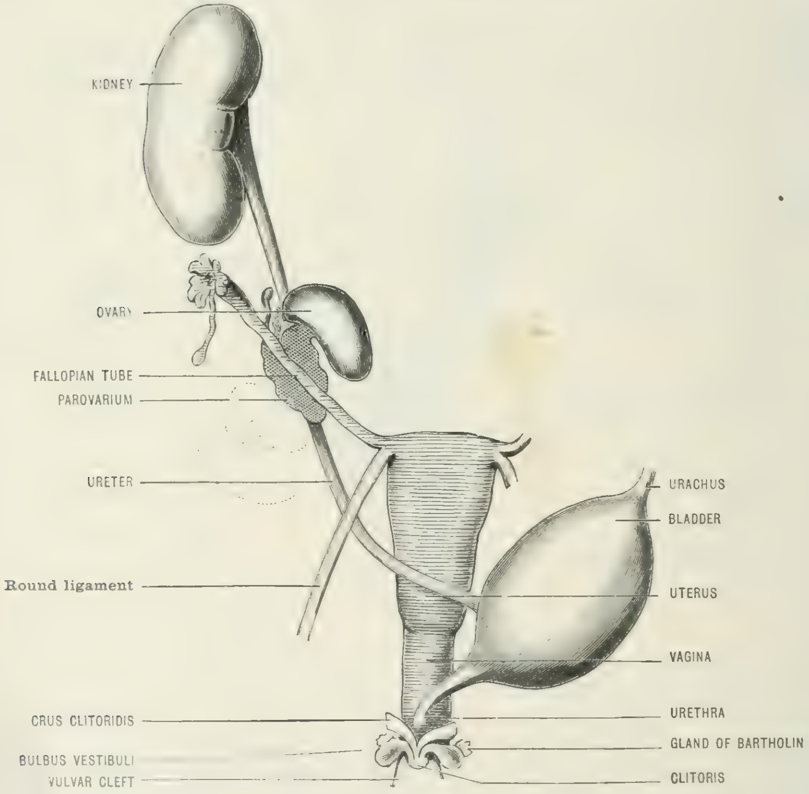
The urinary bladder appears in the second month as a transformation of the pedicle of the allantois, a structure which has already done service in conveying the vessels of the embryo to the placenta. The allantois is a hypoblastic sac invested by a layer of mesoblast, and communicating with the hind gut. That portion of it which lies within the body becomes dilated at its central part into the urinary bladder, but remains narrow at both extremities, forming in front the urachus; and behind, the whole urethra in the female, and the upper part of the prostatic urethra in the male.

The generative apparatus is developed from the Wolffian ducts and from two other paired structures closely related to these, but of somewhat later formation—the Müllerian ducts and the genital glands.

From the **Wolffian body** its tubules and its duct are formed, in the male, the whole of the excretory tubes outside the body of the testicle, namely, the vasa efferentia, the coni vasculosi, the tube of the epididymis, the vas deferens, the ejaculatory duct, and the paradidymis (the organ of Giraldès). In the female the structure dwindles away, leaving its vestiges as the parovarium and the duct of Gärtner (the latter being occasionally demonstrable in the human subject).

Fig. 645.—Development of the Urino-genitive Organs, Female Type. (After Henle.)

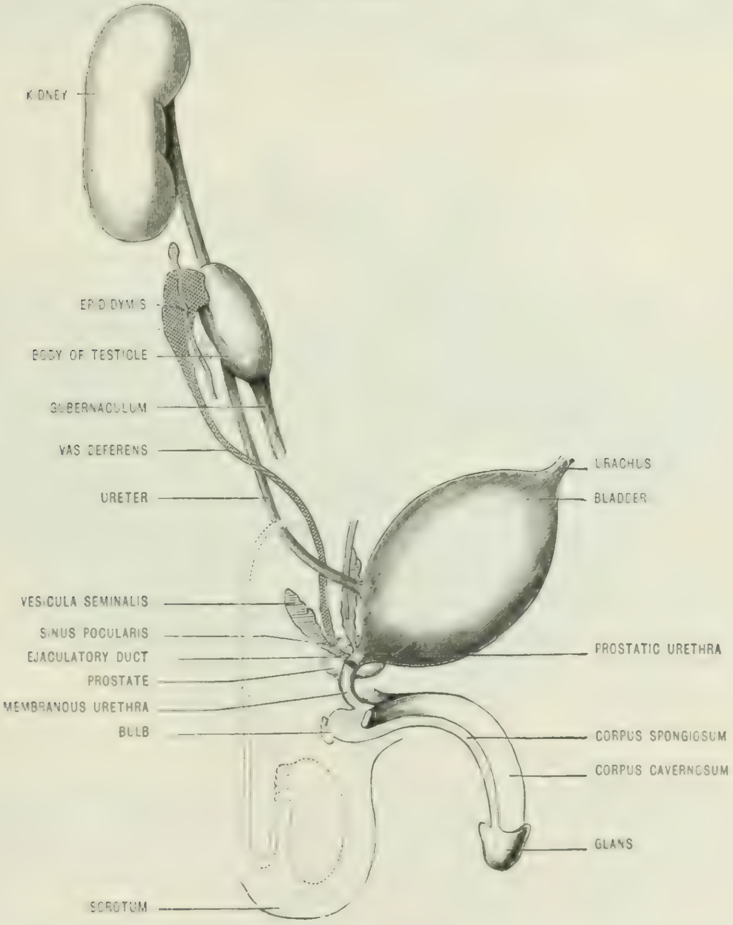
(The parts formed from the Müllerian duct in this and the succeeding diagram are indicated by horizontal shading; those formed from the Wolffian body and duct, by diagonal cross-hatching.)



The **genital gland** arises as a ridge, partly mesoblastic and partly due to a thickening of an epithelial layer, the **germinal epithelium**, on the inner side of the Wolffian body. The cells, at first indeterminate, soon become differentiated to form the Graafian follicles and ova in the female, and the epithelium of the seminiferous tubes in the male; the rest of the ovary or testicle being developed from the mesoblast of the ridge. The gland is at first attached to the Wolffian body. The latter is itself fixed to the posterior wall of the abdominal cavity by a duplicature of peritoneum called the **mesorchium**, or **mesovarium**, from which a little fold containing muscular fibre is prolonged downwards to become the gubernaculum testis in the male, or, after connection with the uterus, the round ligament in the female.

The **Müllerian duct** begins as a slender cord lying parallel to, and on the outer side of, the Wolffian duct. It becomes canalized and opens distally into the cloaca. After a time it fuses with its fellow mesially a short distance above the terminal aperture, and the conjoint tube is bound together with the adjacent Wolffian ducts into a kind of stem called the **genital cord**. In the male the Müllerian duct never appears to discharge any function, and its useless relics are to be traced in the sinus pocularis and hydatid of Morgagni; but in the female it gives rise to nearly the whole of the internal apparatus of generation; its upper extremity, above the line of fusion in the human subject, forming the oviduct and its hydatid appendage, the conjoint tube developing the uterus and vagina. Variations in the point of fusion of the two ducts may lead to the abnormality of a two-horned uterus, or even a double uterus and vagina. Exceptionally Müller's duct may form a rudimentary uterus in the male. In such cases the testes are well developed, but the penis remains very small.

FIG. 646.—DEVELOPMENT OF THE URINO-GENERATIVE ORGANS, MALE TYPE. (After Henle.)



The **external genitals** are developed about the cloacal outlet common to the genito-urinary and intestinal canals. The first change is the appearance of a genital eminence, the future clitoris or penis, at the ventral extremity of the cloacal fissure about the fifth or sixth week. A fortnight later the cloaca is divided by a transverse septum into two parts, a dorsal or anal, and a ventral or uro-genital (**uro-genital sinus**); the septum itself persisting as the perinæal body in the female, and the portion of the perinæum lying between the scrotum and anus in the male. Its absence or incomplete development accounts for certain congenital malformations well known to teratologists. The **uro-genital sinus** next undergoes changes which give the external stamp of sex. At first the urethra opens into the sinus behind the genital prominence. In the **female** this remains permanent, the lips of the sinus expand into the labia majora; two ridges within the sinus, extending one on each side as high as the genital prominence, form the nymphæ; and a little semilunar fold at the entrance of the vagina shows itself in the fifth month and becomes the hymen;

while the genital eminence ceases to enlarge and remains as the clitoris. In the **male** the evolutionary processes go farther. The margins of the uro-genital sinus fuse in the middle line to close in a prolongation of the urethra on the ventral aspect of the genital eminence and to form the scrotum, the process being concluded about the fifteenth week; finally, a pouch of peritoneum makes its way on each side through the abdominal wall into the corresponding half of the scrotum, and into this the testicle ultimately descends, guided by the gubernaculum (page 1025). The glands of Cowper or Bartholin in both sexes are formed by involutions of epithelium near the root of the rudimentary clitoris or penis.

Should the process of mesial fusion fail, the urethra may present a fistulous opening on its ventral side, or may remain cleft from the meatus upwards for a greater or less distance. In the more aggravated forms the defect of union involves the scrotum also, and leads to a spurious hermaphrodism in which is perpetuated a superficial resemblance to the female genitals, the simulation being made greater by the imperfect descent of the testicles. All these congenital defects are clearly accounted for by ascertained facts in morphology; but there is a malformation which our present knowledge does not satisfactorily explain—that known as 'extroversion of the bladder,' in which a non-closure of the ventral parietes below the umbilicus coincides with a fissure in the anterior wall of the allantoic bladder, and leads to an extrusion of the posterior wall of the viscus. Mr. Shattock suggests that the condition is perhaps the result of an undue extension forwards of the cloacal fissure; but the problem cannot yet be regarded as solved.

THE PERINÆUM

The term **perinæum** (*περί, ναίω*) has been variously applied by anatomists—firstly, in its original and general meaning, to the soft parts connected with the pelvic outlet; secondly, to the anterior or genito-urinary segment only of these parts; and thirdly, to the tissues separating the vulvo-vaginal and ano-rectal passages. It is here employed in the first and broader sense, the expression 'perinæum proper' being used for the second application, and that of 'perinæal body' for the third.

The **outlet of the pelvis** is a lozenge-shaped space bounded in front by the symphysis and subpubic ligament, behind by the tip of the coccyx, and on each side by the conjoined rami of os pubis and ischium, the tuber ischii, and the inferior border of the great sacro-sciatic ligament. The latter structure is overlapped to a variable extent by the gluteus maximus, which also covers the tuber ischii when the thighs are extended; but the glutei are merely accessory to the true boundaries.

The dimensions of the outlet in the male and female are given on page 146. The further anatomy of the parts differs in the two sexes.

THE MALE PERINÆUM

The integument of the perinæum is pigmented, beset with scattered hairs, and provided with large sebaceous and sudoriparous glands. Its deeper layers contain an abundance of smooth muscular fibre continuous with the dartos of the scrotum, and these are so disposed around the anal margin as to corrugate the skin into radiating folds during their contraction.

The landmarks of the region are for the most part well-defined. The symphysis in front is obscured by the root of the penis, which may be traced backwards as a soft median prominence as far as a point an inch anterior to the anus. On each side the pubic and ischial rami may be felt running outwards and backwards to expand into the ischial tuberosity, which is uncovered by the gluteus maximus when the thigh is flexed. Extending backwards and inwards from the tuberosity may be detected, in thin subjects, the resistance of the great sacro-sciatic ligament; and still more posteriorly the coccyx is felt in the middle line immediately beneath the skin. The anal aperture, surrounded by radiating furrows, lies a short distance in front of the coccyx, and on each side of it is a depression called the ischio-rectal fossa, the superficial aspect of which depends upon the amount of fat which occupies it.

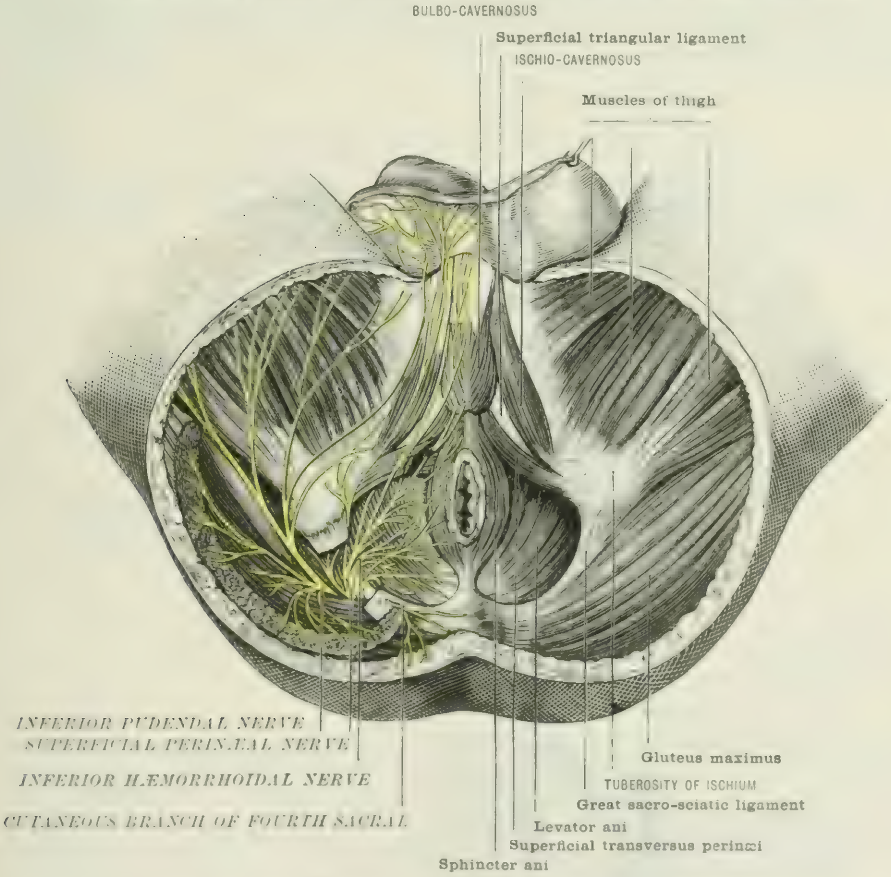
The perinæum is divided arbitrarily into two parts by a line drawn transversely between the two ischial tuberosities an inch in front of the anus. The anterior portion is called the perinæum proper, the posterior the ischio-rectal region. This line, however, does not coincide exactly with the true anatomical boundary as revealed by dissection.

The **ischio-rectal region** comprises the parts surrounding the anus and the ischio-rectal fossæ.

The removal of the integument exposes the sphincter muscle of the anus in the middle line, and on each side, between this and the lateral boundary of the perinæum, the external aperture of the ischio-rectal fossa.

The **sphincter ani externus** is a voluntary muscle surrounding the anus, and attached, in front to the tendinous centre of the perinæum (where it meets the bulbo-cavernosi, the superficial transversi perinæi, and some fasciculi of the levatores ani); behind to the tip of the coccyx. Its fibres are closely connected with the skin, and superficial bundles pass forwards by the sides of the anus, a few decussating with each other across the middle line, and some appear to cross directly over to the opposite side, and around the anus as an annular sphincter. They are pierced by radiating bands of the longitudinal layer of the muscular wall of the rectum, which become lost in the deep layers of the integument.

FIG. 647.—THE MALE PERINÆUM. (Modified from Hirschfeld and Leveillé.)


BULBO-CAVERNOSUS
Superficial triangular ligament
ISCHIO-CAVERNOSUS
Muscles of thigh
INFERIOR PUDENDAL NERVE
SUPERFICIAL PERINÆAL NERVE
INFERIOR HÆMORRHOIDAL NERVE
CUTANEOUS BRANCH OF FOURTH SACRAL
Gluteus maximus
TUBEROSITY OF ISCHIUM
Great sacro-sciatic ligament
Levator ani
Superficial transversus perinæi
Sphincter ani

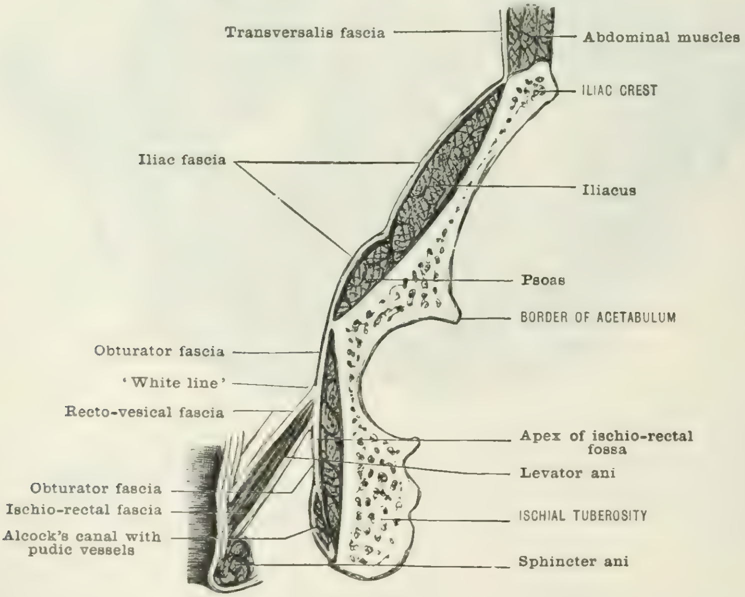
The external sphincter is in relation superficially with the integument, deeply with the levatores ani and internal sphincter; on the outer side with the fat of the ischio-rectal fossa; and internally with the lower portion of the 'internal sphincter' (a thickening of the circular muscle of the rectum), and to a small extent with the rectal mucous membrane. It is supplied by the inferior hæmorrhoidal branches of the internal pudic artery; its veins, of large size and very liable to varicose dilatation, terminate in the inferior hæmorrhoidal and pudic veins; its lymphatics open into the inguinal glands; and its nerves are derived from the perineal, the pudic, and the fourth sacral.

Action.—The external sphincter, by virtue of its elasticity, gives some passive aid to the internal sphincter in maintaining the closure of the anus and the retention of the contents of the rectal *cul-de-sac* under ordinary conditions; but its active and more important function is to close the anal aperture firmly during the contraction of the levatores ani and other constrictor muscles of the abdomino-pelvic cavity in powerful muscular efforts not connected with defecation (as in vomiting, urination, parturition, expiration, etc.). This it effects partly through the approximation of the opposite sides of the anus by its longitudinal fibres, and partly by the ring-like contraction of its circular fibres. It also aids in flexing the coccyx, and in fixing the tendinous centre of the perinæum during the contraction of the bulbo-cavernosi.

THE PELVIC FASCIÆ AND MUSCLES

In order to understand the constitution of the ischio-rectal fossæ and their relation to adjacent parts, it is necessary to review the muscular elements of the pelvic wall, and the arrangement of the pelvic fasciæ.

FIG. 648.—DIAGRAM OF THE PELVIC FASCIÆ.

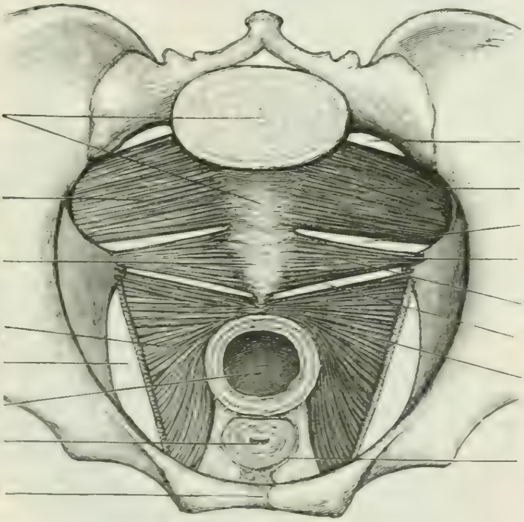

Transversalis fascia
Abdominal muscles
ILIAC CREST
Iliac fascia
Iliacus
Psoas
BORDER OF ACETABULUM
Obturator fascia
'White line'
Recto-vesical fascia
Apex of ischio-rectal fossa
Levator ani
Obturator fascia
Ischio-rectal fascia
ISCHIAL TUBEROSITY
Alcock's canal with pudic vessels
Sphincter ani

The osseo-ligamentous framework of the walls of the true pelvis is constituted by the two ossa innominata below the ilio-pubic line and posterior border of the pubic crest, by the sacrum and coccyx, and by the sacro-sciatic, sacro-iliac, and interpubic ligaments, and the obturator membrane. Supplementing these structures on each side of the median line, are four muscles: the obturator internus, the pyriformis, the coccygeus, and the levator ani, together with their fascial investments.

The obturator internus and pyriformis have already been described (pages 355–358). The fascia covering the inner aspect of the former muscle bears a very important relation to the intrapelvic structures.

The **obturator fascia** (figs. 648, 650) is attached *above* to the ilio-pubic line, as far back as the sacro-iliac joint and to the posterior lip of the crest; *below*, to the back of the symphysis, the inner lip of the lower border of the ischio-pubic ramus, and the inner border of the ischial tuberosity; and *behind* it skirts the osseous border of the great sciatic notch as far as the ischial spine, but at the lesser sciatic notch passes out of the pelvis with the muscle, and appears in the post-femoral region of the thigh. At its borders it is closely related to the fascia iliaca above, the fascia of the pyriformis behind, and the deep triangular ligament below. Its *outer surface* is in contact with the muscular fibres of the obturator internus; its *inner surface* is divided into two portions by a curved band of fibres called the **'white line'** or **arcus tendineus**, extending from the inner aspect of the ischial spine to the back of the os pubis, a little external to the symphysis. The **upper** or **pelvic segment** above the white line is separated from the pelvic viscera by subperitoneal tissue; the **lower or ischio-rectal segment,** below the line, enters into the formation of the outer wall of the ischio-rectal fossa. This portion forms a sheath (canal of Alcock) for the pudic vessels and nerves about an inch above the inner margin of the tuber ischii. The fascia gives off from its inner surface at the white line two thin laminæ: one, the recto-vesical, to the visceral surface of the levator ani; the other, the ischio-rectal, to the parietal aspect of the same muscle.

FIG. 649.—MUSCLES OF THE FLOOR OF THE PELVIS.


SACRUM
Pyriformis
COCCYX
Levator ani divided below the 'white line'
Space for obturator internus
RECTUM
PROSTATE
SYMPHYSIS
Passage for gluteal vessels and nerve
Pyriformis
Passage for sciatic and pudic vessels and nerve
ISCHIAL SPINE
Coccygeus
Cellular interval
Levator ani
Capsule of prostate, and pubo-prostatic ligaments

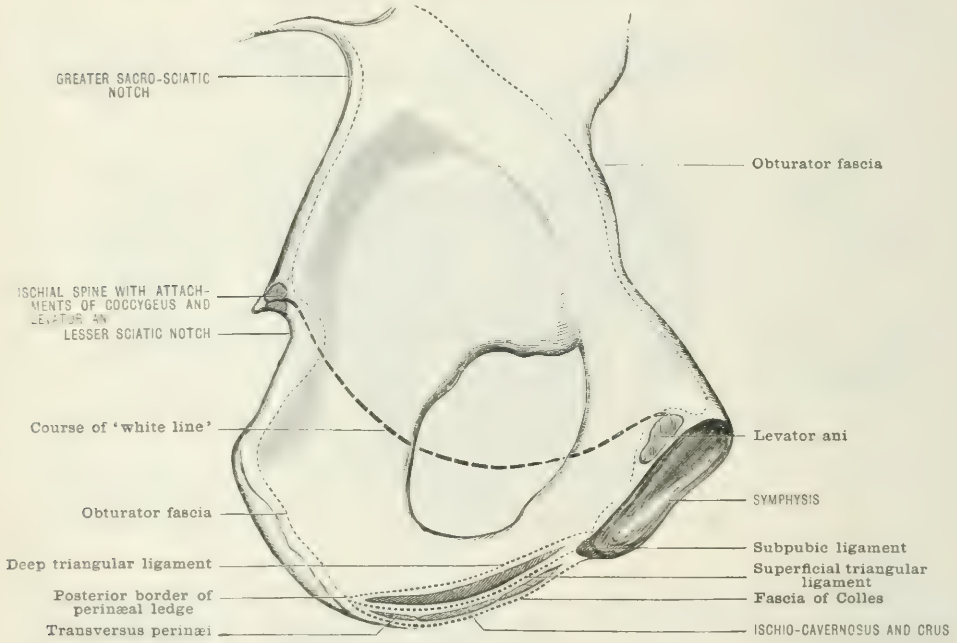
The **levator ani muscle** (figs. 648, 650), with its fellow of the opposite side, constitutes the greater part of the muscular floor of the pelvis, and acts as a septum between the pelvic cavity and the ischio-rectal fossa. It *arises* anteriorly from the back of the os pubis, just external to the attachment of the pubo-vesical muscle, posteriorly from the inner side of the ischial spine below the origin of the coccygeus, and between these two points from the whole length of the 'white line.' Its fibres form a flat plane of considerable strength, and pass downwards, backwards, and inwards to their *insertion*, the most posterior into the tip of the coccyx; those next in order joining the opposite muscle in a median raphe extending from the coccyx to the tendinous centre of the perinæum, and the rest becoming lost upon the side of the rectum, interlacing with the longitudinal layer of the muscular wall of the gut, a few fibres perhaps running in front to the preanal raphe. Its two surfaces may be termed visceral and parietal; the former, looking forwards as well as upwards, is invested by a layer of fascia, the recto-vesical, and is further separated from the lower part of the bladder by subperitoneal tissue; the parietal surface, covered by a fascia, the ischio-rectal or anal, forms the greater part of the outer wall of the ischio-rectal fossa. The anterior and posterior borders of the muscle are free (and here the two investing fasciæ become continuous with each other). The anterior border crosses the side of the prostate, and is connected with the corresponding part of the opposite muscle by fibrous and smooth muscular tissue, which passes between the prostate and rectum. The posterior border is separated from the anterior margin of the coccygeus by an indistinct cellular interspace.

In the female the anterior fibres of insertion are connected with the side of the vagina, interlacing with the longitudinal fibres of its muscular tissue without becoming actually inserted into the passage.

The levator ani is supplied by twigs of the inferior hæmorrhoidal vessels and nerves, and receives also branches from the fourth and fifth sacral nerves.

Action.—The special action from which the muscle derives its name has been questioned by Rüdinger, who believes that its essential function is to compress the rectum. A study of the direction of the fibres, however, leaves little doubt that the result of the contraction of the muscle as a whole, and in association with its fellow, is to draw forwards the coccyx and elevate the pelvic floor and viscera, and thus lessen the long diameter of the abdomino-pelvic cavity and aid in the compression of the abdominal and pelvic viscera. Its action as a compressor of the rectum is probably unimportant, but it is possible that it exercises some influence upon the circulation in the prostatic plexus and in the large pelvic veins which occupy the recess between the muscle and the viscera, and may also assist in the expulsion of the prostatic secretion by direct lateral compression of the organ. In the female it may constrict the lower end of the vagina, where the passage lies between the free borders of the two muscles.

FIG. 650.—DIAGRAM SHOWING LINES OF ATTACHMENT OF THE FASCIÆ AND MUSCLES OF THE PELVIS. (W. A.)

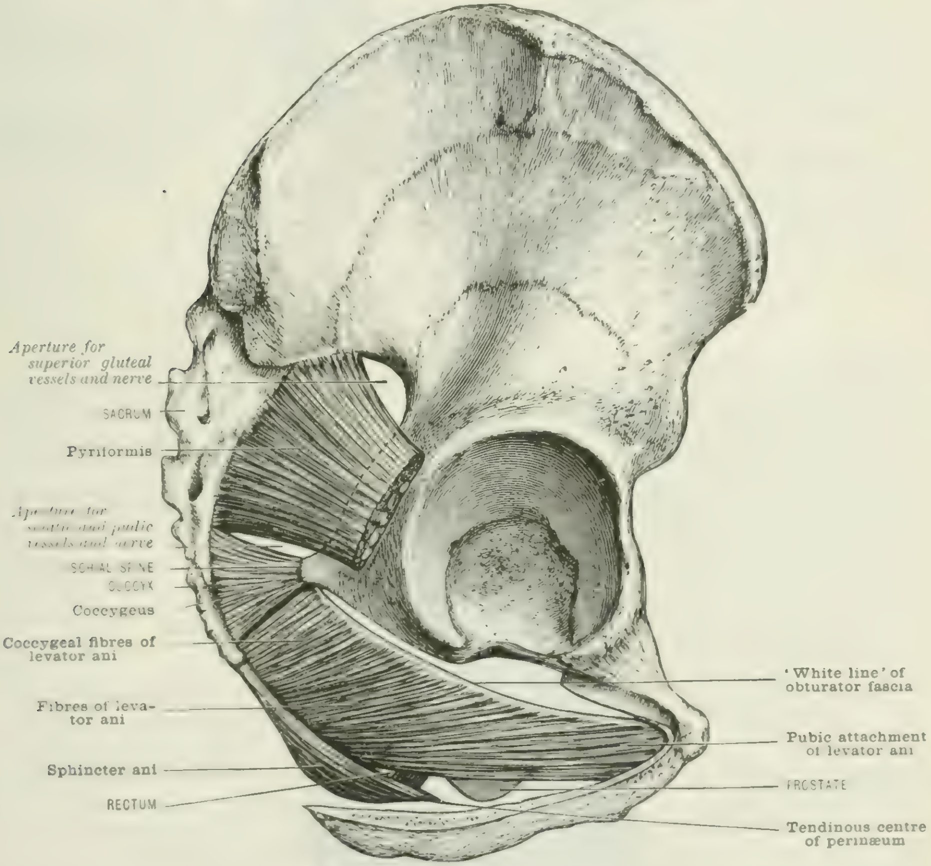

GREATER SACRO-SCIATIC NOTCH
Obturator fascia
ISCHIAL SPINE WITH ATTACHMENTS OF COCCYGEUS AND LEVATOR AN
LESSER SCIATIC NOTCH
Course of 'white line'
Levator ani
SYMPHYSIS
Obturator fascia
Subpubic ligament
Deep triangular ligament
Superficial triangular ligament
Posterior border of perinæal ledge
Fascia of Colles
Transversus perinæi
ISCHIO-CAVERNOSUS AND CRUS

The **coccygeus** is a thin and rather unimportant plane of muscular fibres, supported by and blending intimately with the lesser sacro-sciatic ligament. It arises from the inner surface of the ischial spine above the levator ani, and passes backwards and inwards, expanding to become inserted into the sides of the coccyx, the lateral sacro-coccygeal ligament, and the last two pieces of the sacrum. Its visceral surface looks almost directly forwards and is covered by a continuation of the recto-vesical fascia. Its parietal surface is in contact with the lesser sacro-sciatic ligament. Its superior border is separated from the inferior border of the pyriformis by the vessels and nerves which escape from the pelvis below the latter muscle. Its inferior border is related to the posterior border of the levator ani. The muscle is often pierced by filaments of the fourth and fifth sacral and coccygeal nerves, which supply it and form a kind of plexus on its pelvic surface. It aids the levator ani in drawing forwards the coccyx.

The **recto-vesical fascia** may be regarded as a lamina detached from the obturator fascia at the level of the upper border of the 'white line.' From this point it extends upon the pelvic surface of the levator ani and coccygeus to become reflected upon the viscera immediately related to the muscular floor of the pelvis.

FIG. 651.—MUSCLES OF THE FLOOR OF THE PELVIS. (W. A.)

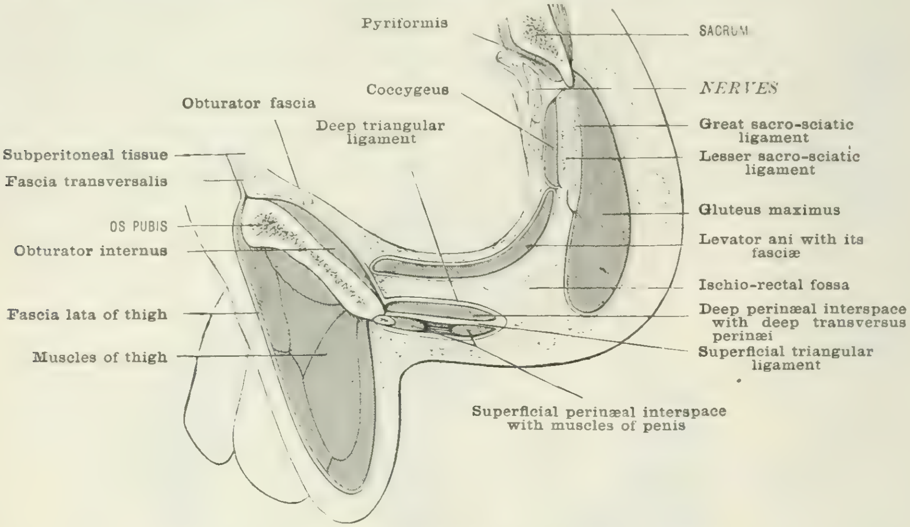
(A portion of the ischial and pubic bones sawn away.)


Aperture for superior gluteal vessels and nerve
SACRUM
Pyriformis
Aperture for sciatic and pudic vessels and nerve
ISCHIAL SPINE
COCCYX
Coccygeus
Coccygeal fibres of levator ani
Fibres of levator ani
Sphincter ani
RECTUM
'White line' of obturator fascia
Pubic attachment of levator ani
PROSTATE
Tendinous centre of perinæum

namely, the prostate and bladder (forming the capsule of the former and the 'true ligaments' of the latter), the vasa deferentia and vesiculæ seminales, the lower part of the rectum, and, in the female, the vagina and uterus. Its visceral portion is easy to trace in the immediate neighbourhood of its reflexion, but it becomes less distinct as it recedes from this point, and at length is undemonstrable.

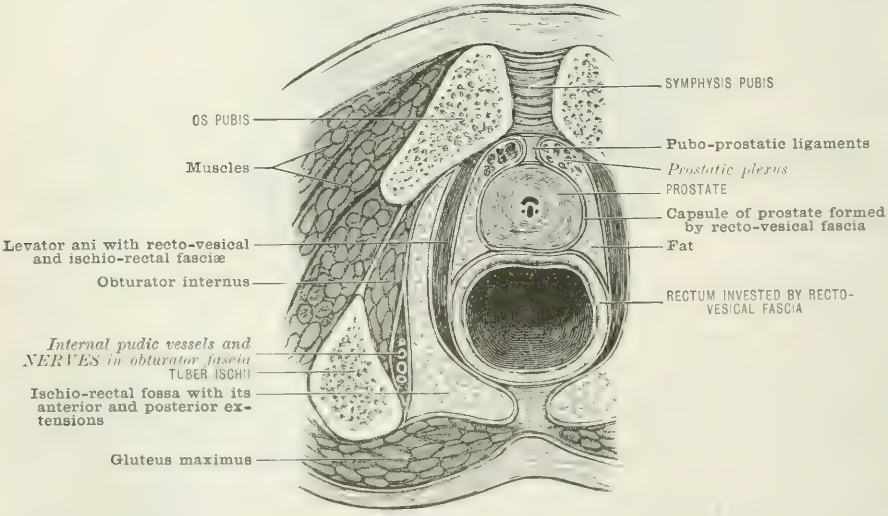
The **ischio-rectal** or **anal fascia**, originating at the white line below the fascial attachment of the levator ani, closely invests the parietal or ischio-rectal surface of this muscle, and that of its neighbour, the coccygeus, to blend in the region of the anus with the deep fascial covering of the external sphincter. In front it passes above the perinæal structures, becoming continuous with the superior triangular ligament (a prolongation of the obturator fascia), and meeting with the recto-vesical fascia, at the anterior border of the levator ani; while behind it extends backwards for a variable distance to join again with the obturator fascia. In this way the two fasciæ, obturator and ischio-rectal, close in the ischio-rectal fossa above, in front, and behind, but leave it widely open below.

FIG. 652.—SAGITTAL SECTION THROUGH THE PERINÆAL LEDGE AND ISCHIO-RECTAL FOSSA TO THE LEFT OF THE MIDDLE LINE. (Diagrammatic.) (W. A.)


Pyriformis
SACRUM
Coccygeus
NERVES
Obturator fascia
Deep triangular ligament
Great sacro-sciatic ligament
Subperitoneal tissue
Lesser sacro-sciatic ligament
Fascia transversalis
OS PUBIS
Gluteus maximus
Obturator internus
Levator ani with its fasciæ
Ischio-rectal fossa
Fascia lata of thigh
Deep perinæal interspace with deep transversus perinæi
Muscles of thigh
Superficial triangular ligament
Superficial perinæal interspace with muscles of penis

The **ischio-rectal fossæ** (figs. 647, 648, 652, 653) are two deep interspaces, one on each side, left by the divergence of the obliquely directed muscles of the pelvic floor (levator ani and coccygeus) from the vertical pelvic wall. Each fossa is bounded *externally* by the obturator internus below the level of the white line, the corresponding portion of the obturator fascia (with Alcock's canal and the pudic vessels and nerves), and the os innominatum; and *internally* by the levator ani and coccygeus and the ischio-rectal fascia. Superiorly, the vertical outer wall

FIG. 653.—SECTION SHOWING THE ISCHIO-RECTAL FOSSA IN ITS RELATIONS TO THE PELVIC VISCERA. (W. A.)


SYMPHYSIS PUBIS
OS PUBIS
Pubo-prostatic ligaments
Muscles
Prostatic plexus
PROSTATE
Capsule of prostate formed by recto-vesical fascia
Levator ani with recto-vesical and ischio-rectal fasciæ
Fat
Obturator internus
RECTUM INVESTED BY RECTO-VESICAL FASCIA
Internal pudic vessels and NERVES in obturator fascia
TUBER ISCHII
Ischio-rectal fossa with its anterior and posterior extensions
Gluteus maximus

is joined by the sloping inner wall where the ischio-rectal fascia joins the obturator fascia, so that the space is angular ʌ in outline in frontal section. So far all anatomists are agreed, but the remaining boundaries require further investigation.

If the finger be introduced into the anterior part of the fossa, it will meet the line of junction of the triangular ligaments with the fascia of Colles; and above this will be found an **anterior recess** of considerable size extending forward nearly as far as the symphysis, between the superior triangular ligament and the under surface of the levator ani, and limited internally by the prostate and pubo-prostatic ligaments, and externally by the pubic and ischial rami. At the back part of the space will be felt the border of the great sacro-sciatic ligament, and above this a **posterior recess** running backwards for a variable distance towards the sacrum. Both of these deep extensions are lined by the ischio-rectal and obturator fasciæ, and filled with fat and connective tissue. The ischio-rectal fossa must then be described as an anvil- or T-shaped cavity with anterior and posterior recesses running the one above the perinæal ledge, the other above the sacro-sciatic ligaments.

Contents.—The ischio-rectal fossa is filled with loose adipose tissue continuous with the subcutaneous fat of the buttock, and traversed from without inwards by the inferior hæmorrhoidal branches of the pudic artery, and by the associated veins and some twigs of the internal pudic nerve passing to the sphincter ani and adjacent skin and mucous membrane.

The veins are usually somewhat dilated near the anal margin, and when morbidly enlarged constitute the condition known as hæmorrhoids or piles. Near the posterior border of the triangular ligaments the pudic vessels and nerves give off their superficial perinæal branches, which almost immediately enter the superficial perinæal interspace.

A small branch of the fourth sacral nerve may be seen turning over the back of the space to reach the anal integument.

THE PERINÆUM PROPER

The **perinæum proper** (figs. 647, 652), considered apart from the portion of the common integument which covers it in, is a curious triangular ledge of tissue stretched almost horizontally across the angular interval between the two ischio-pubic rami. It is pierced by the urethra (and also by the vagina in the female), and comprises three strong fasciæ which enclose within two interfascial spaces the root of the penis with the muscles appended to it, the compressor urethræ muscle, Cowper's glands, and a number of vessels and nerves. Above it lie the prostate and levatores ani with their fasciæ, and the anterior recess of each ischio-rectal fossa.

The perinæal integument has already been described. On removal of the skin with its dartos and the superficial layers of superficial fascia, a deeper plane of fascia will be exposed, connected firmly with the ischio-pubic rami. This is the **fascia of Colles** (the deep layer of the superficial perinæal fascia), the most superficial of the three true perinæal fasciæ.

The **fascia of Colles** is a fibrous lamina of considerable strength. It is attached on each side to the lower margin of the ischio-pubic ramus and to the ischial tuberosity; behind, it turns around the posterior border of the superficial transversus perinæi muscle to fuse with the posterior borders of the superficial and deep triangular ligaments and form the free border of the 'perinæal ledge'; anteriorly, it becomes continuous with the external fascial investment of the scrotum and the fascial covering of the penis.

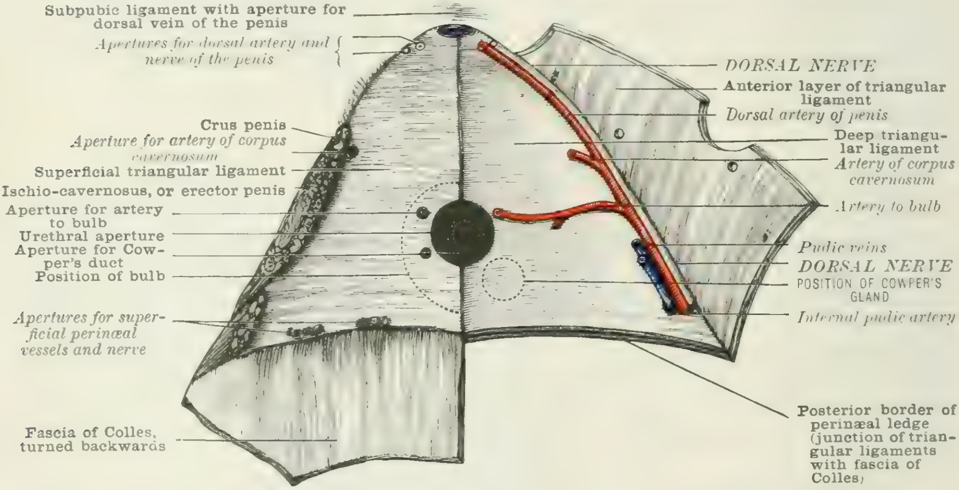
It is between this layer and the inferior triangular ligament that extravasation of urine is especially prone to occur in rupture of the urethra. From its connections it will be seen that the extension of the fluid would be arrested posteriorly and laterally by the connection of the fascia of Colles with the triangular ligaments and with the ischio-pubic rami; but it spreads freely beneath the integuments of the scrotum and of the penis as far as the neck of the glans, and to the surface of the abdomen. On the trunk, it may run in an upward direction even to the axilla, but it is prevented from descending below the groin by the connection of the abdominal fascia with Poupart's ligament and to the margin of the saphenous opening.

Superficial perinæal interspace (figs. 647, 652, 654).—Detaching the fascia of Colles from its connections, the dissector opens the superficial interfascial space and exposes its contents, namely:—(1) The **crura** of the corpora cavernosa with the **ischio-cavernosi**; (2) the **bulb** of the corpus spongiosum with the **bulbo-cavernosi**; (3) the capriciously scattered fibres of the **superficial transversi perinæi**; (4) the **arteries of the corpora cavernosa** and the **dorsal arteries of the penis** with their associated **veins** and **lymphatics**; (5) the **dorsal nerves of the penis**; and (6) the **superficial perinæal vessels and nerves.** The roof of the space (the so-called floor) is formed by the inferior triangular ligament.

The transversi perinæi, the crura penis with the ischio-cavernosi, and the bulb with the bulbo-cavernosi, have been already described (pages 1034, 1035). Each of the muscles named has a fascial sheath of its own, distinct from the fascia of Colles.

The **artery of the corpus cavernosum** enters the crus immediately after piercing the inferior triangular ligament; the **dorsal artery of the penis,** reaching the interfascial space more anteriorly with the dorsal nerve, runs forwards to the dorsum of the united corpora cavernosa to take its place between the vein and nerve; the **superficial perinæal vessels and nerve** given off from the internal pudic trunks in the ischio-rectal fossa enter the interfascial space near the free border of the perinæal ledge. These divide into two sets of branches, posterior or deep, to the penile muscles, and anterior or superficial to the scrotal and perinæal integument; the latter piercing the fascia of Colles and the scrotal investment continuous with it to reach the skin.

FIG. 654.—DIAGRAM OF THE SUPERFICIAL AND DEEP TRIANGULAR LIGAMENTS.


Subpubic ligament with aperture for dorsal vein of the penis
Apertures for dorsal artery and nerve of the penis
Crus penis
Aperture for artery of corpus cavernosum
Superficial triangular ligament
Ischio-cavernosus, or erector penis
Aperture for artery to bulb
Urethral aperture
Aperture for Cowper's duct
Position of bulb
Apertures for superficial perinæal vessels and nerve
Fascia of Colles, turned backwards
DORSAL NERVE
Anterior layer of triangular ligament
Dorsal artery of penis
Deep triangular ligament
Artery of corpus cavernosum
Artery to bulb
Pudic veins
DORSAL NERVE
POSITION OF COWPER'S GLAND
Internal pudic artery
Posterior border of perinæal ledge (junction of triangular ligaments with fascia of Colles)

The superficial perinæal interspace then may be said to contain the root of the penis, with the muscles, vessels, and nerves connected with it.

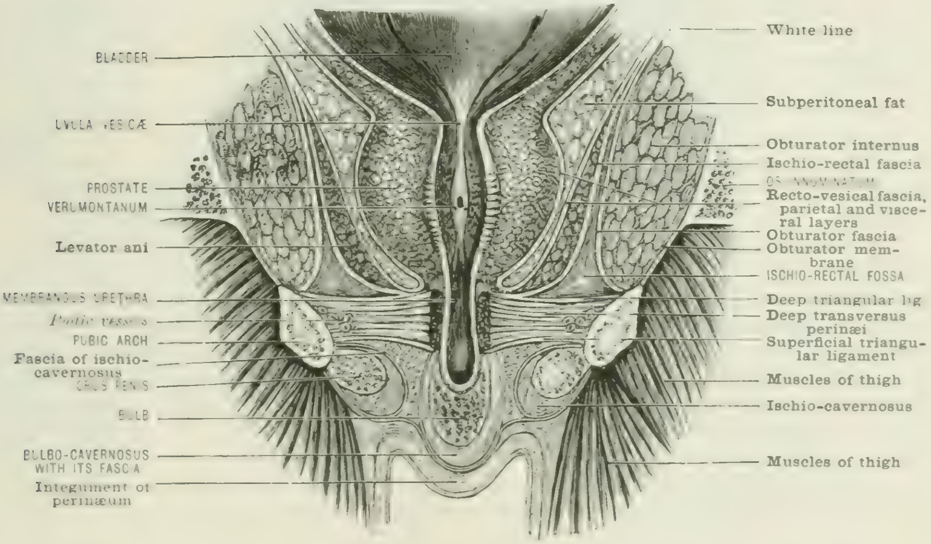
Superficial or inferior triangular ligament ('the anterior layer of the triangular ligament') (fig. 652).—On removing the contents of the superficial interspace the dissector exposes the under surface of the inferior or superficial triangular ligament. This structure forms almost a horizontal plane in the erect posture of the body, and consists of strong bands of fibrous tissue, running for the most part in a transverse direction across the subpubic arch to be attached firmly to the ischio-pubic rami above the line of attachment of the fascia of Colles and of the penile muscles. Anteriorly, it is separated from the subpubic ligament by an interval which transmits the dorsal vein of the penis; posteriorly, it blends with the fascia of Colles and with the superior triangular ligament to form the hinder border of the perinæal ledge; and superiorly it is intimately related to the deep transversus perinæi muscle. It is *pierced* by:—(1) The urethra, about an inch and a quarter below the symphysis; (2) the ducts of Cowper's glands, one on each side of the posterior part of the urethral openings; (3) the arteries of the bulb, somewhat external to the last; (4) the arteries to the corpora cavernosa, more anteriorly and close to the lateral attachment of the ligament; (5) the dorsal arteries and nerves of the penis, at the margins of the ligament near its apex. The dorsal vein with some accompanying lymphatics runs through the interspace between the triangular and subpubic ligaments (fig. 654).

Deep perinæal interspace (figs. 620, 652, 654).—If the superficial triangular ligament be now detached, the deep perinæal interspace will be laid open. This space is somewhat wedge-shaped in sagittal section, in consequence of the manner in which the two triangular ligaments approach each other before their union at the posterior border of the perinæal ledge. It is occupied by the following structures:—

(1) The **membranous urethra,** surrounded by its annular sphincter of smooth muscular fibres.

(2) **Cowper's glands,** seen as two white pea-like bodies, one on each side of the posterior segment of the urethra. Their ducts pierce the superficial ligament.

Fig. 655.—Vertical Frontal Section of the Pelvis, showing Fasciæ.
(Modified from Braune.)


BLADDER
UVULA VESICÆ
PROSTATE
VERUMONTANUM
Levator ani
MEMBRANOUS URETHRA
Pudic vessels
PUBIC ARCH
Fascia of ischio-cavernosus
CRUS PENIS
BULB
BULBO-CAVERNOSUS WITH ITS FASCIA
Integument of perinæum
White line
Subperitoneal fat
Obturator internus
Ischio-rectal fascia
OS INNOMINATUM
Recto-vesical fascia, parietal and visceral layers
Obturator fascia
Obturator membrane
ISCHIO-RECTAL FOSSA
Deep triangular lig
Deep transversus perinæi
Superficial triangular ligament
Muscles of thigh
Ischio-cavernosus
Muscles of thigh

(3) The **internal pudic arteries,** lying close to the ischio-pubic rami imbedded in the fibres of origin of the compressor urethræ muscle, giving off each an artery to the bulb as well as some twigs to Cowper's gland and to the muscular tissue surrounding the urethra, and terminating by division into the artery of the corpus cavernosum, and the dorsal artery of the penis. These branches with the associated veins have been seen to pass through the superficial triangular ligament into the superficial perinæal interspace.

(4) The **pudic veins,** accompanying the arteries. Their tributaries form a plexus around the urethra, and in the substance of the fibres of the deep transversus perinæi. This plexus, which is often largely developed in old persons, receives the veins of the corpus spongiosum and corpora cavernosa, and communicates freely with the dorsal vein of the penis, and through this with the prostatic plexus.

(5) The **pudic lymphatics,** accompanying the veins and terminating in the pelvic glands.

(6) The **dorsal nerves of the penis,** the terminal branches of the internal

pudic nerves, accompany the arteries; each nerve gives off filaments to the deep transversus perinaei, and then pierces the fore part of the superficial triangular ligament with the dorsal artery.

(7) **The deep transversus perinæi, compressor urethræ, or muscle of Guthrie.**—The muscular tissue of the deep perinæal space has been a source of great confusion owing to the multiplicity of the names which have been assigned to various portions of it; but the description given by Henle may be accepted as at once the simplest and the most accurate. The **transversus perinæi profundus** of Henle is closely connected with the superior and inferior triangular ligaments. It arises from the inner surface of the ischio-pubic ramus, by tendinous bundles which separate to form a kind of channel for the pudic vessels and dorsal nerve of the penis, close to the bone. From this origin the greater part of the fibres run across the subpubic angle in a transverse direction in front of and behind the membranous urethra, enclosing Cowper's glands and the deep veins of the penis, and join a more or less indistinct median raphe; while others pass more or less obliquely forwards in front of the urethra and behind the dorsal vein to become attached to the pubic ramus on the side opposite to the bony attachment. A small accessory bundle (the 'sagittal layer' of Henle) may sometimes be found running directly forwards to become inserted into the upper surface of the bulb and into the connective tissue between the corpora cavernosa; and the name 'muscle of Wilson' has been given to a few fasciculi, often difficult to demonstrate, running from the subpubic ligament to the membranous urethra.

The arrangement of the fibres differs considerably in different subjects, and much complexity has been introduced into the study of the muscle by the artificial segregation of certain of its parts under special names, such as levator urethræ, constrictor urethræ, etc.

Its *action* is partly to compress the membranous urethra and thus assist the expulsion of urine and semen, and partly to intercept the flow of blood through the veins of the penis, and so aid in erection. It also exercises compression upon Cowper's glands, and effects the discharge of their secretion during seminal emission. It is supplied by a branch from the dorsal nerve of the penis.

The **deep** or **superior triangular ligament** (figs. 650, 652, 654) is in some sort a prolongation of the obturator fascia across the pubic arch, the continuity of the two fasciæ, however, being interrupted by the attachment of their deep fibres to the inner edges of the ischio-pubic rami. Inferiorly it is in intimate relation with the deep transversus perinæi; while superiorly it forms on each side the floor of the anterior extension of the ischio-rectal fossa; and in the middle line it is separated from the apex of the prostate by a prolongation of recto-vesical fascia, and by a layer of smooth muscular fibre, the **prerectalis** of Henle, in which end the greater part of the anterior longitudinal fibres of the rectum.

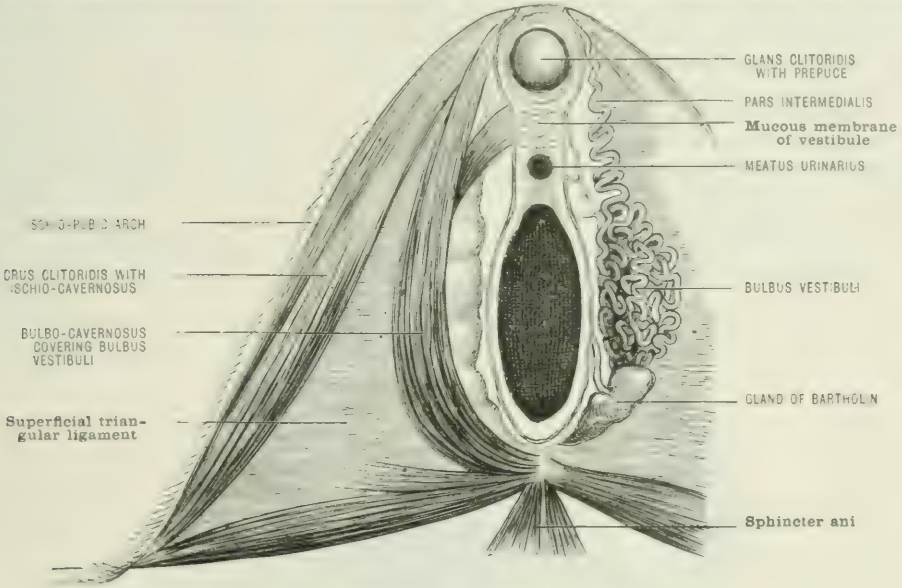
It is *pierced* by the pudic artery and vein and the dorsal nerve of the penis. The dorsal vein of the penis passes between it and the subpubic ligament.

THE FEMALE PERINÆUM

The **female perinæum** (fig. 656) differs from that of the male, partly in the perforation of the whole of its fascial and muscular structures in the middle line by the vulvo-vaginal passage, and partly in the adaptation of the perinæal muscles to the modified conditions of the external genital apparatus. The corpora cavernosa penis are represented by the relatively diminutive **corpora clitoridis**; the ischio-cavernosi are proportionately reduced in size, but differ in no other material respect; the corpus spongiosum is divided into two lateral segments, which are represented by the **bulbi vestibuli** and **partes intermediales**; and the two bulbo-cavernosi are separate, and appear in an attenuated form, spread over the erectile tissue as an attenuated plane of fibres, the **compressor vaginæ**, which is often difficult to recognise on dissection; while the median raphe uniting the two muscles in the male gives place to the **genital fissure.** The **superficial transversi perinæi** differ only in size from those of the male; but the **deep transversus perinæi** is of course cleft by the vagina, and its fibres are relatively thin and weak and in great part unstriped. The **glands of Bartholin,** although morphologically identical with Cowper's glands, are less deeply placed.

The greater development of the connective-tissue structures between the genital canal and the third stage of the rectum, leading to the formation of the **perinæal body,** is also a peculiarity of the female (fig. 619). The perinæal body is triangular in sagittal section, and bounded in front by the vulvo-vaginal wall, behind by the anterior wall of the rectum, and below by the integument between the posterior vulvar commissure and the anal aperture. It consists of a strong meshwork of connective tissue freely intermingled with fibres of elastic tissue and unstriped muscle, and is traversed by the various muscles which meet at the tendinous centre of the perinæum. It becomes stretched to a remarkable degree during the passage of the child's head in labour, but is saved from rupture by its strength and elasticity.

Fig. 656.—Diagrammatic Representation of the Perinæal Structures in the Female.


GLANS CLITORIDIS WITH PREPUCE
PARS INTERMEDIALIS
Mucous membrane of vestibule
MEATUS URINARIUS
ISCHIO-PUBIC ARCH
CRUS CLITORIDIS WITH ISCHIO-CAVERNOSUS
BULBUS VESTIBULI
BULBO-CAVERNOSUS COVERING BULBUS VESTIBULI
GLAND OF BARTHOLIN
Superficial triangular ligament
Sphincter ani

THE MAMMÆ

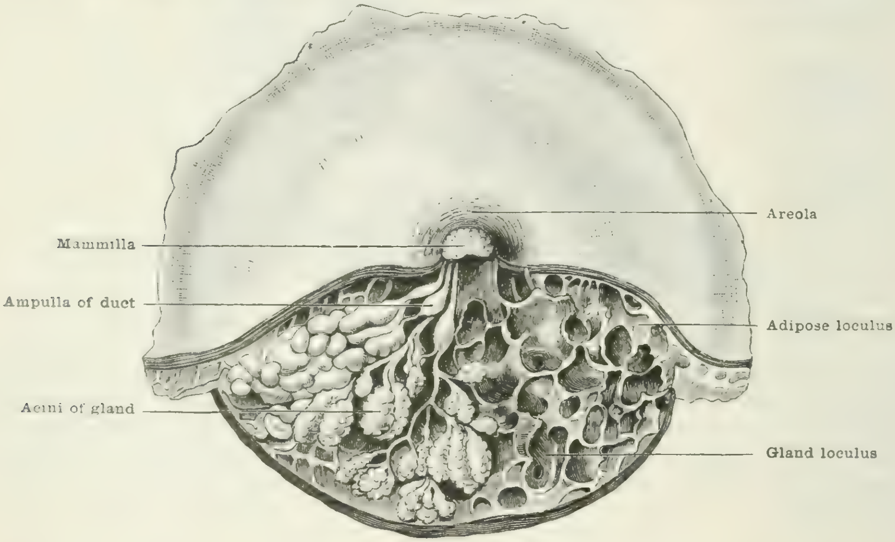
The **mammary glands** are two pectoral organs which secrete the milk in the female, but remain permanently rudimentary and functionless in the male.

The **female mamma** (in which term is included the gland with its investing integumentary structures) is seen in its typical adult form as a more or less hemispherical eminence upon the front wall of the chest over the third, fourth, fifth, and sixth ribs, and extending transversely from the border of the sternum to the anterior margin of the axilla. It is surmounted near its middle by a small wart-like process, the **mammilla** or **nipple,** which lies in the centre of a circular area of altered skin called the **areola.**

The secreting organ consists of an aggregation of ten to sixteen compound racemose glands, the ends of which open separately upon the summit of the nipple. These component elements are quite distinct in the dissected breast as so many lobes of somewhat pyramidal form, with their bases at the periphery and the apices converging towards the mammilla. They are held together and supported by a fibrous capsule, which sends inwards deep interlobular processes, to form a loculated framework for the glandular elements; and superficial processes running to the skin and enclosing supra-mammary fat-containing spaces or **adipose fossæ.** The posterior aspect of the capsule also encloses other fat-spaces (retro-mammary) and is attached to the deep fascia over the pectoralis major by loose connective tissue, the bands of which may be separated by large lymph-spaces, the so-called 'sub-mammary bursæ.' Finally, isolated collections of fat (intra-mammary) may be found buried amidst the lobules of the gland. It is the fat lying in the subcutaneous adipose fossæ and between the gland lobules that gives smoothness and uniformity of surface to the breast, and when it becomes absorbed during lactation or in conditions of emaciation, the lobular structure of the gland is distinctly manifest.

Structurally each of the component lobes may be regarded as a modified sebaceous gland, and hence an appendage of the skin. Each is provided with a single excretory tube (lactiferous or galactophorous duct), which on approaching the nipple is dilated into a **sinus** or **ampulla,** and finally ends by a constricted orifice at the apex of the nipple. The acini and smaller tubes are lined with cubical epithelium, which becomes replaced by columnar cells in the excretory ducts.

FIG. 657.—THE FEMALE MAMMA DURING LACTATION. (After Luschka.)



Accessory glands of small size—half a line to two lines in diameter, and to the number of five to fifteen—are normally found under the skin of the areola, and open on to the summit of the nipple.

The gland as a whole is not circular in outline, but usually presents three cusps—one towards the sternum, sometimes overlapping the bone; the others towards the axilla, one above and the other below; smaller extensions, moreover, pass from the base of the gland to the deep fascia, and may pierce it and lie upon or in the fibres of the pectoral muscle (Heidenhain). These processes are commonly left behind in amputation of the breast, and may form nuclei for recurrent growth in malignant disease.

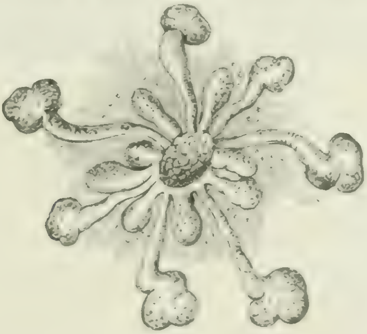
The mammilla and areola are specially modified portions of the mammary integument. The **mammilla** is placed a little internal and inferior to the centre of the gland, and points forwards and outwards. It is of somewhat conical form, averaging about half an inch in length, and terminating by a rounded extremity which is pierced by the orifices of the lactiferous ducts. It is of pinkish colour, and is capable of a kind of erection under the influence of cold, mechanical stimulus, or mental emotion. In some persons it is normally retracted into a depression of the integument, and only projects in response to stimulation.

The **areola** is about an inch in diameter, and is characterised by its pigmentation, the delicacy of its texture, the absence of subcutaneous fat, the large development of its sebaceous and accessory milk glands, and its contractility under the influences which produce erection of the nipple. It is pink in the virgin, but during pregnancy and lactation assumes a brownish shade. The accessory glands, slightly marked in the virgin, form distinct prominences after impregnation (**tubercles of Montgomery**).

The contractility of the nipple and areola is due to the presence of circular and radiating fibres of unstriped muscle in the subcutaneous tissue, the former passing into the substance of the nipple, and forming a network around the lactiferous ducts. The circular fibres by their contraction cause the nipple to project; the radiating fibres retract it.

Variations according to age and functional activity.—At birth the gland is only about one-fifth to one-third of an inch in diameter. The nipple with its dartos is well formed, and the secreting structure is represented by slightly ramified ducts which contain a milky fluid. Growth is slow up to the time of puberty; after this, development progresses rapidly, but no distinct indication of subdivision into lobes is present until impregnation takes place. Some slight engorgement of the breast may, however, occur at the menstrual period, when a yellowish glutinous secretion may sometimes be expelled from the ducts. In pregnancy and during lactation the evolution of the gland-structure is remarkably active. The whole breast enlarges, the superficial fat undergoes absorption, the vessels become dilated and their walls thickened; the areola and nipple increase in size, and the former becomes more or less deeply pigmented. After the end of lactation the breast becomes smaller, but seldom resumes its original condition of smoothness, firmness, and elasticity, and some traces of the pigmentation of the areola remain permanent. In old age the glandular structures atrophy.

FIG. 658.—DEVELOPMENT OF THE MAMMA OF THE FEMALE EMBRYO.
(7 inches in length × 70.) (After Langer.)



The **male breast** differs from that of the female in the early arrest of its evolution. It ranges in diameter from a third of an inch to an inch, and possesses an areola and a nipple, the former often beset with hairs. It is usually placed over the fourth intercostal space, a little internal to the border of the pectoralis major, but its position is very variable, and the two glands are often unsymmetrical. A temporary engorgement occasionally appears in early adult life, and may lead to inflammatory complications.

Vessels and nerves.—The **arteries** are derived from the internal mammary through the second, third, and fourth intercostal spaces, and from the thoracic branches of the axillary. The chief supply is given to the perforating branches of the internal mammary, but the external mammary branch of the axillary artery may be of large size in the female.

The **veins** terminate in the corresponding trunks. The superficial veins become visibly enlarged during pregnancy and lactation.

The **lymphatics,** originating in the cellular interspaces of the gland, form trunks which accompany the veins; the majority terminating in the costal group of axillary glands, the others in the retrosternal chain. The integument of the nipple and areola, as well as the rest of the skin over the mamma, is richly supplied with lymphatics, and as these communicate freely with the vessels of the other side across the middle line, infection may be conveyed to the glands of the side opposite to the primary seat of disease (Volkmann). In cancer of the breast the deep cervical glands about the subclavian vessels may become implicated by extension from the axilla as the disease advances.

The **nerves** are derived from the supraclavicular branches of the cervical plexus, and from the intercostals. The glandular twigs are traced by Eckhard to the fourth, fifth, and sixth intercostals.

Development.—The breast appears about the seventh week of fœtal life as a circular epidermic ridge, enclosing a central depression, the cells of which grow inwards and form branching tubular ducts that radiate beneath the nipple (fig. 658).

Abnormalities.—Small supplementary lacteal glands, in addition to the normal accessory structures beneath the areola, are frequently present around the margin of the principal gland, and may be found in front of the sternum, in the axilla, and below the clavicle, and there is reason to believe that many of the adenomata and cancers take origin in these redundant structures (Roger Williams). Besides these, large supernumerary mammæ, having all the characters of the typical organs, have also been met with in various situations—in the axilla, over the back, the abdomen, and even on the thigh. These are in all probability atavistic. Absence of the mamma is extremely rare.

The **nipples** may be double, or even triple on each breast, or may be wanting altogether.

In a few instances an abnormal development of the gland tissue has been known to occur in the male, and milk has been secreted in sufficient quantity to nourish an infant. A slight and temporary enlargement of the gland about the period of puberty is not infrequent.

THE SKIN

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The skin is a membranous investment forming the entire external surface of the body and its members, and is continuous at certain points with the internal lining of the alimentary, respiratory, and urinogenital canals.

Its *extent* has been estimated at about 15,000 square cm. in an adult male of medium size (Sappey). In *thickness* it varies considerably in different portions of the surface, ranging from $\frac{1}{50}$ to $\frac{1}{12}$ of an inch (0·5 to 2 mm.), but appears to be proportionate to the amount of pressure or friction to which the parts are habitually subjected. Thus it is thickest upon the nape, back, and shoulders, and on the palms and soles, while on the front of the trunk and on the dorsal aspect of the hands and feet it is relatively thin. It is highly elastic and is capable of stretching to a considerable extent without rupture of its continuity, and of regaining its original condition when the extending force is removed. This quality is especially remarkable in the distension of the integuments over a slow-growing tumour. Its *colour* is due partly to pigmentation, partly to the blood within its vessels. The amount of pigment varies with race, sex, age, and with exposure to sun and air; and is normally greater in certain portions of the skin (axilla, scrotum, vulva, mammary areolæ, etc.) than on the rest of the surface, besides being subject to physiological and pathological variations. Its *surface* is for the most part smooth, but is diversified by the orifices of glands, by the growth of hair, and by various furrows and elevations. Permanent linear **ridges** are present upon the palms and soles, and flexor surfaces of the digits; and temporary papular elevations ('goose-flesh') may appear in the positions of the hair-follicles under the influences of cold or emotion. The permanent ridges, corresponding to rows of dermic papillæ, have an arrangement of a peculiar kind over the front of the terminal joints of the fingers, and their variations have been classified in such a manner as to prove valuable for purposes of identification. In primitive races the imprint of the thumb has been used as a kind of signature.

The **furrows** or **depressions** are of several kinds. The most permanent are those which separate the papillary ridges on the palm. Relaxed portions of the skin, such as that of the back of the hand during extension of the wrist and fingers, are crossed by a multitude of fine decussating **wrinkles**, which disappear when the surface is stretched; other lines of a more constant type are produced by joint flexion, such as those in front of the wrist; others are caused by contraction of voluntary or involuntary muscles, such as the lines of expression on the forehead space, the transverse wrinkles on the scrotum, and the radiating folds around the anus, the lines then running at right angles to the direction of the muscular fibres by which they are produced; lastly, a complex wrinkling of the skin appears in old age or in the course of exhausting diseases, partly as a result of loss of elasticity of the structures and partly from absorption of the cutaneous and subcutaneous fat.

In addition to these linear depressions are more rounded forms, called **dimples**, some of which, as those on the chin and cheeks and at the ulnar border of the palm, correspond to the points of attachment of muscular fibres into the deep surface of the skin, and are made evident by the contraction of these fibres; while others depend upon the attachment of the skin by fibrous bands to the bony eminences, as of the elbow, shoulder, vertebræ, and posterior iliac spines, and are seen only when the subcutaneous adipose tissue is well developed.

The skin is separated from the superficial bones and muscles, etc., by a subcutaneous structure, comprising white fibrous and elastic tissues, fat, and, in certain situations, layers of striped or unstriped muscle. The subcutaneous fibrous tissue over the greater part of the body is arranged in two planes, known as the superficial and deep layers of the **superficial fascia,** separated by a layer of fat. It is closely blended with the deep aspect of the skin, but only loosely united to the deep fascia investing the muscles, and permits the cutaneous and subcutaneous structures to move more or less freely over the deep parts. In some situations, moreover, where the integument is exposed to repeated friction over subjacent bones or other hard structures, its movements are facilitated by the development of sac-like interspaces in the subcutaneous tissue, called **bursæ.** Exceptions to this rule of mobility of integument are found in the head and face, where the skin is intimately connected with the subjacent muscular and tendinous tissues, and in the palms and soles, where it is firmly attached to the deep fascia.

The **subcutaneous fat** varies considerably in amount and character in different parts of the body. It is entirely absent on the penis and scrotum and is largely developed over the nates, palms, and soles, where it serves as pads or cushions. In the scalp it appears as a single uniform layer of ovoid lobules between the derm and the aponeurosis of the occipito-frontalis muscles; on other parts of the surface it is somewhat unequally distributed, and shows a tendency to accumulate in apparent disproportion in certain localities, as on the abdomen, over the symphysis pubis, about the mammæ in females, etc. Everywhere, except perhaps on the scalp, it may undergo rapid and visible increase or decrease under the influence of changes of nutrition.

The subcutaneous planes of **striped muscle** are comparatively scanty in man when compared with the great panniculus carnosus of the lower mammalia. They are best represented by the platysma myoides on the neck. **Unstriped muscular fibre,** present in all parts of the skin as an appendage to the hair-follicles and sebaceous glands, is found also in some parts of the subcutaneous tissue, as in the scrotum and perinæum, around the anus, in the mammilla, and beneath the mammary areola.

Structure of the skin.—The skin is separable into two distinct layers—a deeper, the derm, cutis vera, or corium; and a more superficial, the epiderm, cuticle, or scarf-skin. The latter, morphologically representing the epiblast, is a purely epithelial cell-growth, while the derm, which is developed from the mesoblast, is of highly complex organisation.

The **derm** is composed of elastic fibrous tissue intermixed with fat vesicles, and bundles of unstriped muscular fibres, traversed by a rich plexus of blood and lymph-vessels and of nerves, and enclosing hair bulbs and sebaceous and sudoriparous glands. The superficial layers are of finer structure, free from fat, and form a multitude of eminences, called **papillæ,** which project upwards into corresponding depressions in the substance of the epiderm. The fibrous bands composing the deeper layers are coarser and less compact, intermingled with fat lobules, and pass without any definite line of demarcation into the subcutaneous tissue. The **muscular fibres** appear as appendages to the hair and its sebaceous follicles, and are known as **arrectores pilorum.** Two or three bundles are attached to each hair-sheath below the sebaceous gland opening into the follicle, and are so arranged as to be capable of compressing the acini of the gland, and of rendering the direction of the hair-shaft somewhat more perpendicular to the surface from which it emerges. This latter action produces the 'bristling of the hair' which is believed to be one of the manifestations of extreme terror, but which occurs in many persons in association with mental excitement of various kinds.

The fibrous tissue runs for the most part in bundles parallel to the surface, intercrossing at various angles in a manner that appears to be regulated upon a definite plan. Langer and others have shown that if the skin is punctured by an awl, the aperture left on withdrawing the implement is not round, but linear or angular. On the scalp, forehead, chin, and epigastrium a triangular or ragged hole is produced, while over the rest of the body the 'cleavage' is linear, the lines affecting a direction nearly at right angles to the long axis of the limbs, and on the trunk running obliquely downwards, and outwards from the spine. The linear cleavage indicates that the bundles run mainly in one direction, while the 'incomplete' cleavage is associated with a crossing in all directions. The arrangement of the vessels of the skin is said to be governed by the cleavage, and the form and distribution of certain skin eruptions are probably connected with these factors.

The **papillæ** are very closely set—from 36 to 130, according to Sappey, lying within a square millimetre. The largest are found in the palm and sole and under the nail, reaching a height of half a line or a line (1 to 2 mm.); the smallest, distributed over the face, scrotum, and mammillæ, having only a third or a fourth of these dimensions. The forms usually assumed are those of simple cones, but some are slightly bulbous at their free extremities; others have duplicated apices, and those about the palmar and plantar surfaces of the hands and feet form long curvilinear ridges, which are pierced by the orifices of the sweat ducts, and separated from each other by furrows. It is only in these latter situations that the arrangement of the papillæ is unconcealed by the epidermis. Structurally, the papilla consists of a delicate fibrous tissue containing vessels and nerves, or, in certain situations, a special tactile body. Its subepidermic surface and that of the interpapillary depressions is modified into a delicate, structureless lamina, called the **membrana basilaris.**

The **epiderm,** or cuticle, is a layer of varying depth, the thickness being regulated chiefly by the amount of pressure or friction to which the part is habitually subjected. Its deep aspect is moulded to the papillary layer of the derm, while its free surface gives little or no indication of the papillary eminences except on the palms and soles, but it displays numberless apertures of glands and hair-follicles, which it lines with tubular prolongations. Structurally, it consists entirely of epithelial cells of various shapes. The component cells may be divided into five distinct layers, arranged from within outwards in the following order: (1) The **stratum basilare,** or generative layer, consists of a single set of nucleated, prismatic cells, the denticulated bases of which rest upon the basement membrane of the derm. (2) The **stratum Malpighii,** succeeding this, is a soft, relatively thick layer, composed of several ranges of nucleated cells, polyhedral in shape, denticulated on all sides, and separated from each other by fine intercellular channels, in which may be lymph corpuscles and even pigment. The cells are the seat of the pigment granules which give to the skin a portion of its colour. (3) The **stratum granulosum** comprises two or three layers of transitional cells, resembling those of the stratum Malpighii in the denticulation of their opposed sides, but flattened in the direction of the surface and containing a number of minute granules, which readily take the stain of carmine or logwood, and are composed of a peculiar substance, called **eleidin,** or **kerato-hyalin,** that is said to be the active agent in the keratinic transformation of the more superficial cells, and is, perhaps, to be regarded as the earliest product of the retrograde change which ends in keratinisation. (4) The overlying layer, the **stratum lucidum** of Oehl, represents the first stage of the horny change. It is seen in sections of the skin as a transparent band, which on close examination is found to be made up of colourless cells with indistinct marginal denticulation and atrophic nuclei, and flattened in the direction of the surface. (5) The superficial layer, the **stratum corneum,** is not very sharply defined from the last, and shows a further advance in the horny degeneration, if such a term may be applied to a purposeful and necessary change. The cells are highly keratinised, and appear as thin, transparent scales, from which both denticulation and nucleation have disappeared, the latter, however, still being traceable after maceration in dilute alkalies.

The life history of the epidermis appears to be that of a continuous genesis, from the stratum basilare, of new cells which rise slowly towards the surface to assume in succession the characters of the cells in the older stratum above, and become in turn replaced by their successors from below, until, having passed through all the grades leading to complete keratinisation, their career is ended and they are cast off from the stratum corneum. No vessels exist in any part of the epiderm, but nerve-fibrils are said to penetrate as far as the stratum Malpighii.

In the more recent methods of skin-grafting the surgeon takes a plane which usually includes all the layers of the epidermis, and even the extreme tips of the papillæ of the derm (as shown by the minute bleeding points left on the surface from which the graft has been cut). The absence of the deeper and more highly vitalised epidermic cells in the pellicle separated by a blister is probably responsible for the almost uniform failure of transplantation of this material.

VESSELS OF THE SKIN

The **arteries of the skin** form a network in the subcutaneous tissue, and from this arise branches which pass outwards into the derm, and, after supplying twigs to the glands and hair-bulbs, unite into a second network beneath the papillæ, supplying these latter with fine arterioles, which finally break up into a capillary plexus. The **veins** commencing within the papillæ form a subpapillary network which ends in the subcutaneous veins. The lymphatics have a like arrangement.

Nerves.—The skin is richly supplied with nerves, but in varying degrees in different regions. Everywhere the nerves form plexuses in the derm, the network becoming finer as it approaches the epiderm, forming a rich subepithelial network immediately beneath the stratum basilare. From this, delicate fibrils have been traced outwards as far as the stratum Malpighii, where they terminate. The integumentary nerves end in three different ways—some in subcutaneous bodies, the corpuscles of Pacini or Vater; others in dermic structures, the corpuscles of Meissner and Krause; and a third, or epidermic set, are believed to terminate in minute bulbs.

The **corpuscles of Pacini** may be found attached, like berries, to the nerve-stems lying in the subcutaneous tissue in various parts of the surface, but most abundantly on the digital nerves. They are not confined to the cutaneous nerves, but are seen also upon mixed nerves, such as the intercostal; upon articular, periosteal, and other nerves; and even on sympathetic filaments, such as those of the mesentery. They are of oval form, and range in size from $\frac{1}{25}$ to $\frac{1}{5}$ of an inch (1 to 5 mm.). Structurally, they consist of a connective-tissue envelope derived from the perineurium and a series of thirty to sixty concentric fibrous tunics each, lined on both sides by endothelium; within is a central structureless core. The nerve-fibre pierces one of the poles of the corpuscle and reaches the central core, where it loses its myelin and subdivides into delicate ramifications, which end in small bulbous enlargements. Each body is supplied by a set of vessels that form plexuses and loops in the layers of the capsule.

The **tactile corpuscles of Meissner** are of smaller size and more limited distribution than the Pacinian bodies. They belong almost entirely to the hands and feet, but may be found also over the radial side of the forearm, in the mammilla and the red border of the lips, as well as in the free border of the conjunctiva and in the mucous membrane of the tip of the tongue. They are particularly numerous over the pulp of the terminal phalanges, where the sense of touch is most acute. They lie within certain of the papillæ, which they occupy to the exclusion of vessels, and appear as solid, olive-shaped bodies about $\frac{1}{25}$ of an inch in length ($\frac{1}{10}$ of a mm.) placed with their long axes at right angles to the surface. Each is joined at its deeper extremity by one, two, or more nerves. In structure the corpuscle consists of a connective-tissue capsule, like that of the Pacinian body, derived from the perineurium; within this is a solid cellular structure, in which the nerve cylinder, deprived of its myelin, breaks up into filaments, to end either in bulbous or discoid enlargements.

The **spheroidal end-bulbs of Krause,** found in the conjunctiva and mucous membrane, and in a modified form in the prepuce and glans penis and clitoridis, bear some resemblance to the tactile corpuscles and to the central core of the Pacinian bodies. They consist of a connective-tissue capsule enclosing a cellular structure in which the nerve terminates.

THE APPENDAGES OF THE SKIN

Under this heading are included sudoriparous and sebaceous glands, hair, and nails. The **sudoriparous glands,** which secrete the sweat, and probably a certain amount of oily matter in addition, have their origin in a single coiled tube, which forms a spheroidal glomerulus in the deeper part of the derm, or even in the subcutaneous tissue, and is continued into an excretory duct that pierces the interpapillary spaces of the derm, and traverses the epiderm in a sinuous or spiral course to open on the surface. They are most numerous on the palms and soles, least so on the back of the neck and trunk and on the lower limbs. Sappey estimates the total number over the whole body at 2,000,000. The glomeruli range from one two-hundred and fiftieth of an inch (0·1 mm.) to a line (2 mm.) in diameter, and are largest in the axilla and groin and about the mammary areola. The tube wall consists of an epithelial layer of prismatic nucleated cells, supported partly by an incomplete layer of cells, believed to be those of unstriped muscular fibre, partly by a structureless membrana propria lying outside the last and continuous with the basement membrane of the derm. The 'muscular' layer is absent in the excretory duct. Allied to the sudoriparous glands are the **ceruminous glands** of the external auditory meatus, which have the same structure, but primitively open into the hair-follicles; and the **ciliary glands** of Moll, opening on the free border of the lids, which do not form glomeruli.

The **sebaceous glands** are found over the whole area of the skin except on the palms and soles. They differ from the sudoriparous glands in their racemose form, in their almost constant relation to the hairs, in the oily nature of their secretion, and in their comparatively superficial position. The greater number discharge their contents into the hair-follicles, one, two, or more being attached to each hair; others open directly on to the surface, and either present a rudimentary hair emerging from the excretory duct or are altogether unconnected with hairs, as in the labia minora and mammary areola. It is these last which attain the greatest size. Their acini are invested by bands of unstriped muscles which aid in the expulsion of their contents, and in the case of the larger hairs act as 'arrectores pilorum.'

The **nails** are essentially an epidermic specialisation. Rudimentary in man, they are largely developed in many of the lower animals, taking the form of claws or hoofs. In man the nail appears as a horny plate on the dorsal aspect of the terminal phalanx of the digit; it is straight, or nearly so, in its longitudinal axis, but curved in the opposite direction, with the convexity outwards. The entire nail is divided into a **root,** thin, soft, and buried in a fold of skin; a **body,** hard and keratinised, longitudinally ridged on its dorsal aspect, and extending from the root to the line at which the appendage ceases to be connected with the skin; and a **free extremity,** which, unless restrained by artificial means, tends to grow into a claw-like form and may curve over strongly towards the palmar surface of the digit. The point at which this joins the pulp of the finger is called the **angle.**

The colour of the nail varies in its different parts. The greater part of the body has a pinkish tint which may be expelled by pressure, and depends upon the vessels beneath; but near the root is a white crescent, the **lunula,** most largely developed on the thumb, least on the little finger, where it is often concealed by the overlapping border. The free extremity is semitransparent and almost colourless.

The surface of the nail, especially that of the thumb, may under certain circumstances present transverse furrows and ridges corresponding to irregularities of nutrition; and as the growth of the entire length of the nail occupies on the average about six months, it is sometimes possible to surmise roughly, by an ungual inspection, the physical history of the person within that period.

Hairs.—Man, like the rest of the mammalia, is a hairy animal, but the greater part of his hirsute covering assumes the form of a scarcely visible down. It attains a considerable development only in certain regions, and it is lacking on the flexor surface of the hands and feet and their digits, on the back of the terminal phalanges, and at certain reflections of the integument, as the prepuce and glans penis, the inner aspect of the labia majora and the labia minora. The distribution of larger and smaller hairs in the two sexes is too familiar to require description. The direction taken by the hairs in the various parts of the body is fairly constant and may be traced in each region to or from certain centres or **vortices**, such as those upon the crown of the head, at the external auditory meatus, in the axilla, the fold of the groin, and elsewhere.

The hair not only varies in character and development in different parts of the surface, but presents considerable racial and individual variations in each region. Taking the hair of the head as a type, we may find it either straight, wavy, curled into incomplete or complete spirals, or minutely tufted like wool, and each of these varieties is associated with peculiarities in the transverse sectional area; thus, in the straightest hair the section is circular or nearly so, while in the wavy, curly, and woolly hair it is oval or elliptical, the greatest difference between the largest and smallest diameters being found in the woolly hair in which the radius of the curve is smallest. In length the highest development is attained in straight hair, and the growth is nearly always greater in the female than in the male. In some regions the growth becomes luxuriant from infancy; in others, as upon the pubic regions in both sexes and on the lips and cheeks of the male, its full development is deferred until puberty or later. As age advances, the hair-bulbs are liable to undergo premature atrophy upon the summit of the head in men, while the growth may continue to progress in other parts of the body, even to extreme senility; and a loss of pigment in the hair, usually beginning on the head and extending later in a somewhat capricious way to the other regions of the body, is another sign of local failure of nutrition which may or may not be associated with senile degeneration of the tissues generally. Pathologically, the hair is subject to many changes, into which it is not necessary to enter here.

The first growth of hair begins about the fifth month of fœtal life, but this crop (**lanugo**) is entirely shed within a few months of birth. The process of shedding and new formation goes on throughout life.

The typical hair has its root in a dermic papilla sunken at the bottom of a deep follicle which runs more or less obliquely through the whole or greater part of the thickness of the skin. The **hair-follicle** is cylindrical or oval in section and fairly uniform in diameter in the greater part of its length, but expanding below where it contains the bulb of the hair. Into it open the orifices of the sebaceous glands appended to the hair; very rarely also the duct of a sweat-gland.

Structurally, the follicle consists of an invagination of the elements of the skin, with the addition of a partial lining derived from the generative papillæ of the hair; and its wall comprises three laminæ. The **external** or **dermic** coat is continuous with the derm, and is composed of two layers of fibrous tissue, the more external being longitudinal in direction, the inner transverse. At the bottom of the follicle it is reflected upwards as the **papilla,** which constitutes the essential and generative element of the hair-root. The middle or **hyaline** coat is an invagination of the structureless basement membrane, upon which rest the deepest cells of the epidermis. This becomes lost upon the papilla. The internal **epithelial coat** is divided into two secondary layers called, respectively, the outer and inner root-sheaths. The **outer root-sheath,** from the opening of the follicle down to the openings of the sebaceous ducts, includes all the layers of the epidermis, but below this point loses the stratum granulosum and the stratum corneum, and is reduced to the stratum Malpighii and stratum basilare. The **inner root-sheath,** unrepresented in the epiderm and probably a derivative of the hair-papilla, consists of three layers: the **layer of Henle,** formed by a single set of polyhedral cells; the **layer of Huxley,** similarly constituted, but with the component cells more elongated and less closely compacted; and the **cuticular layer,** composed of a single set of thin, imbricating cells, clear and transparent, with atrophic nuclei.

The **hair proper** is a cylindrical or oval shaft expanded below into a bulb, where it caps the papilla, at the bottom of the follicle. The **shaft,** fairly uniform in diameter in the scalp-hairs, consists of a medullary axis, surrounded by a cortical coat and invested by a cuticular layer. The **medulla,** constituting about one-fourth of the entire diameter of the hair, is a solid cylinder, white by reflected light, dark by transmitted light, and is composed of closely compacted nucleated cells, filled with pigmentary and fatty granules and air-bubbles. It is formed below by a layer of cells which enclose and crown the papilla. Downy hairs are devoid of medulla. The **cortex** consists of a layer of fusiform cells elongated in the direction of the hair, and these, like the medullary cells, are nucleated and contain pigmentary granules. The **epidermis** or **cuticle** is a layer of scaly epithelial cells, arranged like the tiles of a roof, but with the overlapping edges directed upwards. Owing to this peculiar imbrication the edges of the cells of the buried part of the shaft may become reversed when the hair is pulled out of its follicle, and may then present a deceptive appearance like that of fusiform fibres rolled spirally around a stem.

As the shaft structures approach the papilla they gradually change their character. The bulb itself consists of an **inner layer** of prismatic cells lying directly in contact with the dermic papilla, and representing the stratum basilare of the epidermis; a **middle layer** of polyhedral cells like those of the stratum Malpighii, and an **outer layer** of keratinising cells corresponding to the stratum granulosum, but devoid of eleidin.

The **papilla** is a cone of connective tissue into the centre of which is prolonged a vascular loop from the subcutaneous plexus. Nerves are not seen in the papilla, but fine twigs have been traced into the deeper part of the follicular wall, there losing their myelin and forming terminal fibrils, some longitudinally, some circularly arranged, outside the hyalin layer. The special tactile hairs of the lower animals present a more complex nervous and vascular apparatus, but these are not represented in man.

SECTION X

ON SURGICAL
AND
TOPOGRAPHICAL ANATOMY

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SUPERFICIAL ANATOMY OF THE HEAD AND NECK

THE CRANIUM AND SCALP

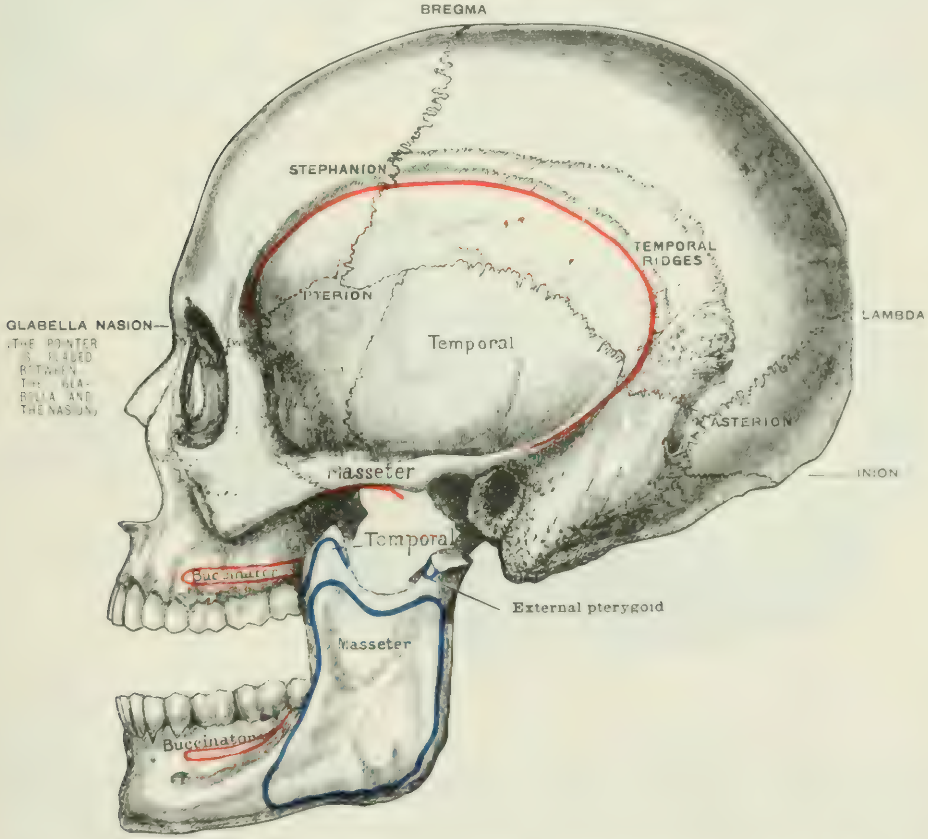
Bony landmarks.—These should be studied with the aid of a skull, as well as on the living subject. In the middle line, behind, is the external occipital protuberance, or **inion,** the thickest part of the vault, and corresponding internally with the meeting-point of six sinuses. From this point the superior curved lines pass out towards the mastoid processes, and indicate the first part of the course of the lateral sinuses, which, after running horizontally outwards, turn downwards in the mastoid bone. The position of these important vessels would be more correctly indicated by a line drawn first from the external occipital protuberance to the upper border of the mastoid process, one inch behind the external auditory meatus. This line gives the transverse and longer part of the sinus. A shorter line, from the ending of the first to the tip of the mastoid, will indicate by its upper two-thirds the sigmoid portion of the sinus and the bend by which it communicates with the transverse part (Macewen). (Fig. 660.)

About two inches and three-quarters (68 mm.) above the external occipital protuberance is the **lambda,** or meeting of the sagittal and lambdoidal sutures (posterior fontanelle, small and triradiate in shape). It is useful to remember, as guides on the scalp to the above two important points, that the lambda is on a level with the supraciliary ridges, and the external occipital protuberance on one with the zygomatic arches.

The point of junction of the lambdoidal and squamous sutures, the **asterion,** is placed about three-quarters of an inch behind and half an inch above the upper part of the posterior border of the mastoid (fig. 659). The **bregma,** or junction of the coronal, sagittal, and, in early life, the frontal suture (anterior fontanelle, large and lozenge-shaped), lies just in front of the centre of a line drawn transversely over the cranial vault from one preauricular point to the other (fig. 659). The **pterion,** or junction of the frontal, parietal, temporal, and sphenoid bones, lies in the temporal fossa, one and a half to two inches behind the external angular process of the frontal, and about the same distance above the zygoma (fig. 659). This spot also gives the position of the trunk and the anterior and larger division of the middle meningeal artery. The zygoma can be traced backwards to its roots in front of the ear, while from its anterior extremity the finger, carried upwards along the outline of the malar, traces the temporal ridge along the side of the skull which marks the upper limit of the temporal fossa, and the attachments of the temporal muscle and fascia. In the temporal fossa lie the muscle, and the deep temporal vessels and nerves. Above the zygoma can be felt the contraction of the temporal; and below, that of the masseter muscle; the former less distinctly owing to its covering of fascia, attached below by two layers to the upper border of the zygoma. In the zygomatic fossa, lying inside the zygoma, are the lower part of the temporal, and the two pterygoid muscles, together with the internal maxillary vessels, and the mandibular division of the fifth nerve, and their branches.

The anterior inferior angle of the parietal bone, and its great importance as a landmark, has already been given. The posterior inferior angle of this bone (grooved by the lateral sinus) lies a little above and behind the base of the mastoid, on a level with the roots of the zygoma (fig. 659). Just below and in front of the tip of the mastoid the transverse process of the atlas can be made out in a spare subject.

FIG. 659.—THE SKULL.

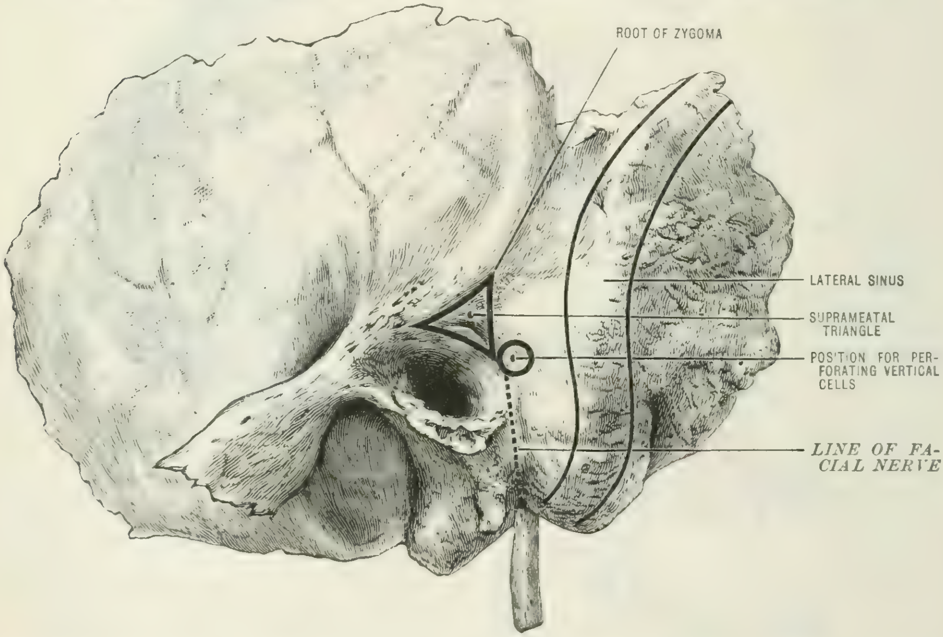

BREGMA
STEPHANION
TEMPORAL RIDGES
PTERION
GLABELLA NASION
(THE POINTER IS PLACED BETWEEN THE GLABELLA AND THE NASION)
Temporal
LAMBDA
ASTERION
Masseter
INION
Temporal
Buccinator
External pterygoid
Masseter
Buccinator

The average thickness of the adult skull-cap is about one-fifth of an inch (Holden). The thickest part is at the external occipital protuberance, where the bone is often three-quarters of an inch in thickness. The thinnest part of the skull vault is over the temporal part of the squamous. The extreme fragility of the skull here is partly compensated for by the thickness of the soft parts; of these, the pericranium is alone thinner than elsewhere, while its intimate connection with the bones make cephalhæmatoma less frequent here (Tillaux).

In front, the circumference of the bony orbit can be traced in its whole extent. The supraorbital notch lies at the junction of the inner and middle thirds of the supraorbital arch. When this notch is a complete foramen, its detection is much less easy. Above the supraorbital arch is the supraciliary ridge, and higher still the frontal eminence. From the supraorbital notch, a line drawn downwards and slightly outwards, so as to run between the two bicuspid teeth in each jaw, passes over the infraorbital and mental foramina (Holden). The infraorbital foramen lies about a quarter of an inch below the margin of the orbit. The mental foramen in the adult is placed midway between the upper and lower margins of the jaw, and 'is a little over a quarter of an inch below the *cul-de-sac* of mucous membrane between the lower lip and the jaw' (Treves).

THE BONY SINUSES.—The frontal.—The development of these by the twentieth or twenty-fifth year may render a fracture here much less grave in the adult than would otherwise be the case, the inner table, if now separated from the outer, protecting the brain. Mr. Hilton showed that the absence of any external prominence here does not necessarily imply the absence of a sinus, as this may be formed by retrocession of the internal table. In old people these sinuses may enlarge by the inner table following the shrinking brain. Again, a very prominent bump here does not necessarily point to the existence of a sinus at all, being due merely to a heaping up of bone.

FIG. 660.—TEMPORAL BONE, SHOWING SUPRAMEATAL TRIANGLE. (Barr.)



When well developed, the frontal sinuses may reach two inches upwards and one and a half inches outwards, occupying the greater part of the vertical portion of the frontal bone. When very small, they scarcely extend above the nasal process. Even when present, they are often asymmetrical. The sinuses are separated by a septum. Each sinus narrows downwards into the infundibulum. This 'is deeply placed behind the nasal process of the maxilla and near the inner wall of the orbit. Its termination in the middle meatus is about on a level with the palpebral fissure' (Thane and Godlee).

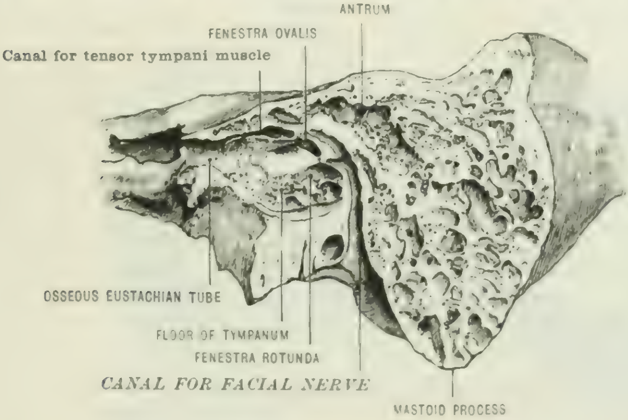
The communication of these sinuses with the nose accounts for the frontal headache in ozæna, and the fact that a patient with a compound fracture opening up the sinuses can blow out a flame held close by.

The **mastoid sinuses** are arranged in two groups, of the utmost importance in that frequent and fatal disease, inflammation of the middle ear :—(A) The **upper**, or '**antrum**,' present both in early and late life, horizontal in direction, closely adjacent to and communicating with the tympanum. (B) The **lower**, or **vertical**. This group is not developed in early life.

A. **Mastoid antrum** (figs. 660 and 661).—This is a small chamber lying behind the tympanum, into the upper and back part of which (tympanic attic) it opens. Its size varies, especially with age. Present at birth, it reaches its largest size (that of a pea) about the third or fourth year. After this, its size usually diminishes somewhat, owing to the development of the encroaching bone around it. Its **roof**, the tegmen antri, is merely the backward continuation of the tegmen tympani. The level of this is indicated by the posterior root of the zygoma. 'The level of the floor of the adult skull at the tegmen antri is, on an average, less than one-fourth of an inch above the roof of the external osseous meatus; in children and adolescents, from one-sixteenth to one-eighth of an inch' (Macewen).

The **outer wall** of the antrum is formed by a plate descending from the squamous bone. This is very thin in early life, but as it develops by deposit from the periosteum, the depth of the antrum from the surface increases. Macewen gives the average of the depth as varying from one-eighth to three-fourths of an inch. At the junction of the two parts of the outer wall of the mastoid cells is the masto-squamosal suture, often present at puberty. Through the **floor**, the antrum communicates with the lower or vertical cells of the mastoid. This floor is on a lower level than the opening into the tympanum, and thus drainage of the antrum is difficult, fluid finding its way more readily into the lower cells. **Behind** the mastoid antrum and cells is the bend of the sigmoid part of the lateral sinus, with its short descending portion (fig. 660). Macewen gives the following guides for this part of the sinus : '(1) A line drawn from the parieto-squamo-mastoid junction to the tip of the mastoid. (2) In the adult, a vertical line drawn one-half of an inch behind the posterior bony wall of the external auditory meatus, and between the levels of the roof and the floor, will, in the majority of cases, indicate the position of the anterior convexity of the sigmoid sinus.' The same authority gives the following directions for exploring this important vessel : 'An opening in the bone, with its posterior margin touching the line drawn from the parieto-squamo-mastoid junction to the tip of the mastoid, and within the parallels of the roof and floor of the external auditory meatus, will expose the part of the sigmoid sinus most often affected with septic thrombosis.' The sinus lies more superficially than the antrum, being usually one-fourth of an inch, occasionally only one-half of an inch, from the surface.

FIG. 661.—SAGITTAL SECTION THROUGH ROOF AND FLOOR OF TYMPANIC CAVITY.

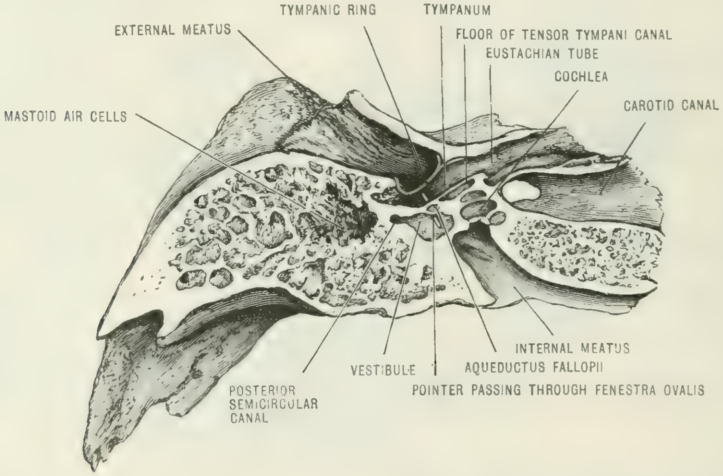


The exact position of the antrum, a little above and behind the external auditory meatus, is represented by Macewen's 'suprameatal triangle.' This is a triangle bounded by the posterior root of the zygoma above, the upper and posterior segment of the bony external meatus below, and an imaginary line joining the above boundaries (fig. 660). 'Roughly speaking, if the orifice of the external osseous meatus be bisected horizontally, the upper half would be on the level of the mastoid antrum. If this segment be again bisected vertically, its posterior half would again correspond to the junction of the antrum and middle ear, and immediately behind this lies the suprameatal fossa' (Macewen). When opening the antrum through this triangle, the operator should work forwards, and inwards, so as to avoid the sigmoid sinus (fig. 660); while, to avoid the facial nerve (fig. 660), he should bring the root of the zygoma and the upper part of the bony meatus as close as possible. The level of the base of the brain will be a few lines above the posterior root of the zygoma (fig. 659) and about one-quarter of an inch above the roof of the bony meatus (Macewen).

B. **The lower or vertical cells of the mastoid** are developed later than is the antrum, and vary much in their contents. In only about twenty per cent. do they contain air.

The *veins passing from the mastoid cells and tympanum* fall into three chief groups —(*a*) those opening into the lateral sinus; (*b*) those passing through the mastoid foramen into the occipital and scalp veins; (*c*) those running through the petro-squamosal suture to the dura mater. As all these veins carry connective-tissue sheaths, inflammation may reach—(*a*) the lateral sinus, causing septic phlebitis; (*b*) the soft parts outside, causing cellulitis, periostitis, etc.; (*c*) the dura mater and brain, leading to meningitis and abscess.

FIG. 662.—HORIZONTAL SECTION OF LEFT TEMPORAL BONE, SHOWING THE VARIOUS PARTS OF THE EAR.



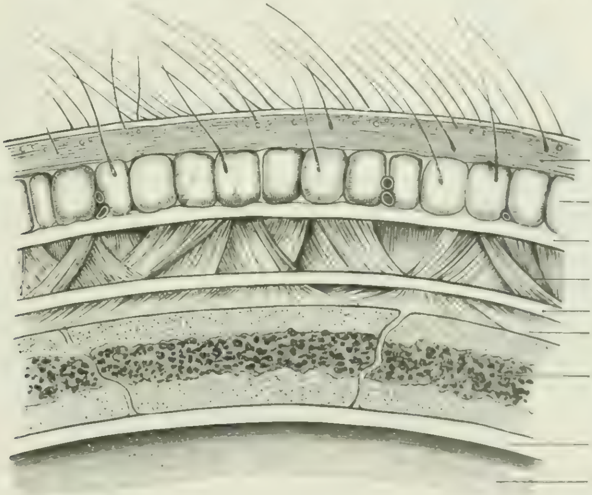
The **sphenoidal sinuses** are less important surgically, but these points should be remembered:—(1) Fracture through them may lead to bleeding from the nose, which is thus brought into communication with the middle fossa; (2) the communication of their mucous membrane with that of the nose may explain the inveteracy of certain cases of ozæna; (3) here and in the frontal sinuses very dense exostoses are sometimes formed.

THE SCALP.—The importance of the **scalp** is best seen from an examination of its **layers** (fig. 663). These are—(1) **skin**; (2) **subcutaneous fat** and **fibrous tissue**; (3) the **occipito-frontalis** and **aponeurosis**; (4) the **sub-aponeurotic layer** of connective tissue; (5) the **pericranium** and **subpericranial connective tissue.**

The first three layers are connected and move together. (1) The union of the **skin,** and its density, are to enable it to meet pressure, and also to prevent it rucking into folds. Furthermore, they account for the extreme pain of inflammation here, and the difficulty of raising a blister on the scalp. The presence of

hairs and sebaceous glands is of much more importance than appears at first. Thus the rooting of the former is so firm that in the case of young women the whole scalp may be torn off by machinery. The **sebaceous glands** have also grave importance. If in removing them the aponeurosis beneath is pricked or the wound becomes foul, fatal suppuration in the 'dangerous area' beneath may follow. (2) The **subcutaneous fat** is arranged much as in the palm, viz. tough fatty pellets are enclosed in fibrous partitions, dipping from the skin to the third layer, and thus tying the three layers together. (3) The **occipito-frontalis and its aponeurosis** have been fully described elsewhere (page 427). (4) The **subaponeurotic layer** of connective tissue. The characters of this layer are quite opposed to those of the layer of connective tissue above the aponeurosis. It is loose, delicate, and fatless. From these result the free mobility of the scalp, the fact that it can be torn away, and (most important of all) the facility with which inflammatory products can spread in this layer. The perils of pus pent up here are extreme, viz. sloughing of the scalp, or necrosis of the bones, blood-poisoning, and meningitis, from mischief travelling along the emissary and diploic veins (fig. 663). The continuity of the different scalp layers by bands of connective tissue passing from the skin to the occipito-frontalis, and thence along vessels, emissary and others, into the venous sinuses, or by the diploic veins within the skull, will account for scalp inflammation reaching the meninges.

FIG. 663.—SECTION THROUGH THE SCALP, SKULL, AND DURA MATER. (Tillaux.)


Skin and superficial fascia with hair bulbs and sebaceous glands
Fat pellets
Occipito-frontalis aponeurosis
Subaponeurotic connective tissue
Pericranium
Subpericranial connective tissue
SKULL: DIPLOIC TISSUE
Dura mater
Skull cavity

Of the **vessels of the scalp**, the arteries are peculiar in their position. Thus they lie superficial to the deep fascia, which is here represented by the aponeurosis (fig. 663). From this position arises the fact that a large flap of scalp may be separated without perishing, as it carries its own blood-vessels. From the density of the layer in which the vessels run they cannot retract and are difficult to seize, haemorrhage thus being free. Finally, from their position over closely adjacent bone, ill-applied pressure may easily lead to sloughing.

The emissary veins.—These are communications between the sinuses within and the veins outside the cranium. Most of them are temporary, corresponding to the chief period of growth of the brain. Thus in early life, when the development of the brain has to be very rapid, owing to the approaching closure of its case, a free escape of blood is most essential, especially in children, with their sudden explosions of laughter and passionate crying.

1. Vein through the foramen cæcum, between the anterior extremity of the superior longitudinal sinus and the nasal mucous membrane. The value of this temporary outlet is well seen in the timely profuse epistaxis of children. Other more permanent communications between the skull cavity and nasal mucous mem-

brane pass through the ethmoid and internal orbital foramina. The fact that the nasal mucous membrane is loose and ill-supported on the turbinated bones allows its vessels to give way readily, and thus forms a salutary safeguard to the brain, warding off many an attack of apoplexy.

2. Vein through the mastoid foramen, between the lateral sinus and the posterior auricular and occipital veins. This is the largest, the most constant, and the most superficial of the emissary veins. Hence the old rule of applying blisters or leeches over it in cerebral congestion.

3. Vein through the posterior superior angle of the parietal between the superior longitudinal sinus and the veins of the scalp.

4. Vein through the posterior condyloid foramen between the lateral sinus and the deep veins of the neck.

5. Vein through the anterior condyloid foramen between the occipital sinus and the deep veins of the neck.

6. Ophthalmic veins communicating with the cavernous sinus and the angular vein. These veins may be the source of fatal blood-poisoning, by conveying out of reach septic material, in acute periostitis of the orbit, or in osteitis, of dental origin, of the jaws.

7. Minute veins through the foramen ovale between the cavernous sinus and the pharyngeal and pterygoid veins.

8. Communications between the frontal diploic and supraorbital veins, between the anterior temporal diploic and deep temporal veins, and between the posterior temporal and occipital diploic veins and the lateral sinus.

The gravity of these emissary veins and their free communications with others is shown by the readiness with which they become the seat of septic thrombosis, and thus of blood-poisoning, in cranial injuries, erysipelas, suppuration of the scalp, and necrosis of the skull.

Structure of cranium.—Two layers and intervening **cancellous tissue.** Each layer has special properties. The **outer** gives thickness, smoothness, and uniformity, and, above all, elasticity. The **inner** is whiter, thinner, less regular—e.g. the depressions for vessels, Pacchionian bodies, dura mater, and brain. Its chief characteristics are its fragility (vitreous) and absolute inelasticity. The **diploë**, formed by absorption after the skull has attained a certain thickness, reduces the weight of the skull without proportionately reducing its strength, and provides a material which will prevent the transmission of vibrations.

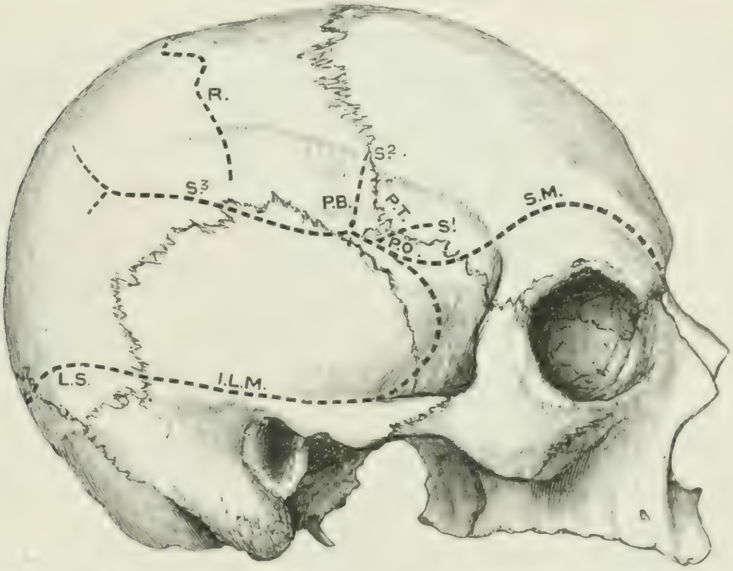
Results of the above varying elasticity.—A blow on the head may fracture the internal table only, the external one and diploë escaping. This is difficult to diagnose, and thus it is impossible to judge of the severity of a fracture from the state of the external table. This may be whole, or merely cracked, while the internal shows many fragments, which may set up meningitis, or other mischief.

Anatomical conditions tending to minimise the effects of violence inflicted upon the skull.—(1) The **density** and **mobility of the scalp.** (2) The **dome-like shape of the skull.** This, like an egg-shell, is calculated to bear relatively hard blows and also to allow them to glide off. (3) The **number of bones** tends to break up the force of a blow. (4) The **sutures** interrupt the transmission of violence. (5) The **internal membrane** (remains of fœtal periosteum) acts, in early life, as a linear buffer. (6) The **elasticity of the outer table.** (7) The **overlapping of some bones,** e.g. the parietal by the squamous; and the alternate bevelling of adjacent bones, e.g. at the coronal suture. (8) The **presence of ribs,** or **groins,** e.g. (*a*) from the crista galli to the internal occipital protuberance; (*b*) from the root of the nose to the zygoma; (*c*) the temporal ridge from orbit to mastoid; (*d*) from mastoid to mastoid; (*e*) from the external occipital protuberance to the foramen magnum. (9) **Buttresses,** e.g. malar and zygomatic processes, and the greater wing of the sphenoid. (10) The **mobility** of the head upon the spine.

CRANIO-CEREBRAL TOPOGRAPHY

To make as clear as possible the points of practical importance which have, of late years, been put on a definite basis, and which the surgeon may have to recall and act upon at very short notice, cranio-cerebral topography will be spoken of under the following headings: A. **Relation of the brain as a whole to the skull.** B. **Relation of the chief sulci and convolutions to the skull.** C. **Localisation of the chief sulci and convolutions.** Before alluding to the above, it is necessary to say distinctly that the following surface-markings and points of guidance are only approximately reliable, for the following reasons: (1) In two individuals of the same age and sex the sulci and convolutions are never precisely alike. (2) The relations of the convolutions and sulci to the surface vary in different individuals. (3) That as the surface area of the scalp and outer aspect of the skull are greater than the surface area of the brain, and as the convexities do not tally, lines drawn on the scalp or skull cannot always correspond precisely to cerebral convolutions or sulci. It results from the above that when a definite area of the surface is said to correspond accurately in any individual to a definite area of the brain surface, this result has been correlated from many examinations; and that as surface-markings, shape, and processes of skull and arrangement of brain surface are all liable to variations in different individuals, the surgeon must allow for these variations by removing more than that definite area of skull which is said to correspond exactly to that part of the brain which he desires to expose.

FIG. 664.—THE OUTLINE OF THE BRAIN AND ITS FISSURES IN RELATION TO THE SUTURES OF THE SKULL. (Cunningham.)



S.M. Supraciliary margin of the cerebrum. I.L.M. Infero-lateral margin of the cerebrum. L.S. Position of highest part of the arch of the lateral sinus. R. Fissure of Rolando. S¹. Anterior horizontal limb of Sylvian fissure. S². Anterior ascending limb of Sylvian fissure. S³. Posterior horizontal limb of Sylvian fissure. P.B. Pars basilaris of the inferior frontal convolution. P.T. Pars triangularis of the inferior frontal convolution. P.O. Pars orbitalis of the inferior frontal convolution.

A. **Relation of the brain as a whole to the skull** (figs. 664 and 665).—Traced from before backwards, *the lower level of each cerebral hemisphere* would follow a line across the forehead, slightly curved upwards above the eyebrows, crossing from the forehead to the temple immediately above the external angular process of the frontal. It then descends slightly along a line now convex forwards in the front of the temporal fossa to about the centre of the upper margin of the zygomatic arch. From this point a line should be drawn just above the external auditory meatus to the external occipital protuberance. To trace the lower level of the brain more precisely on the skull, the chalk would start from the lower part of the glabella; thence the line pursues a course, slightly curved upwards, about a third of an inch above the supraorbital margin; next, crossing the temporal crest about half an inch above the external angular process, it passes not quite horizontally, but descending slightly to a point in the temporal fossa just below the tip of the great wing of the sphenoid (pterion), an inch behind the external angular process. From this point the line of the level of the brain, now convex forwards and corresponding to the anterior extremity of the temporo-sphenoidal lobe, would dip down, still within the great wing of the sphenoid, to about the centre of the zygoma. Thence the line would travel along the upper border of this process about a quarter of an inch above the roof of the external auditory meatus, and thence just above the base of the mastoid and the posterior inferior angle of the parietal, and so along the superior curved line, and corresponding to that of the tentorium and horizontal part of the lateral sinus, to the external occipital protuberance.

The **upper margin of each hemisphere** would be represented by a line drawn from just below the glabella, sufficiently to one side of the middle line to allow for the falx and superior longitudinal sinus, to one immediately above the superior external occipital protuberance and inion (p. 1091).

B. **Relation of the chief fissures and convolutions to the skull. Localization of the chief sulci and convolutions.** These headings will be taken together.

It will be well to first indicate the position of the chief **sutures** which mark off the parietal bone, under which lies that part of the brain which is most important to the surgeon—the motor area. The upper limit of the bone will be indicated by the line already spoken of as giving the upper margin of the hemisphere—the **sagittal line,** or **suture** (p. 1091). The anterior limit of the parietal bone, formed by the **coronal suture,** may be traced thus: The point where it leaves the sagittal suture (the bregma) will be found by drawing a line from a point just in front of the external auditory meatus (the preauricular point) (p. 1091, figs. 659 and 665) straight upwards on to the vertex; from this point a line drawn downwards and forwards to the middle of the zygomatic arch would indicate that of the coronal suture. Under this suture lie the posterior extremities of the three lateral frontal convolutions; for the frontal lobe lies not only under the frontal bone, but extends backwards under the anterior part of the parietal, the fissure of Rolando, which separates the frontal from the parietal lobe, lying from one and a half to two inches behind the coronal suture.

The squamoso-parietal suture, which marks the lower border of the anterior two-thirds of the parietal bone, is not so easy to define, owing to the irregularity and variations of its curve. Its highest point is usually one and three-quarter inches above the zygoma.

The lambdoid suture, which forms the posterior boundary of the parietal bone, will be marked out by a line which starts from a point (lambda) two and three-quarter inches above the external occipital protuberance, and runs downwards and forwards to a point on a level with the zygoma, one and three-quarter inches behind the meatus.

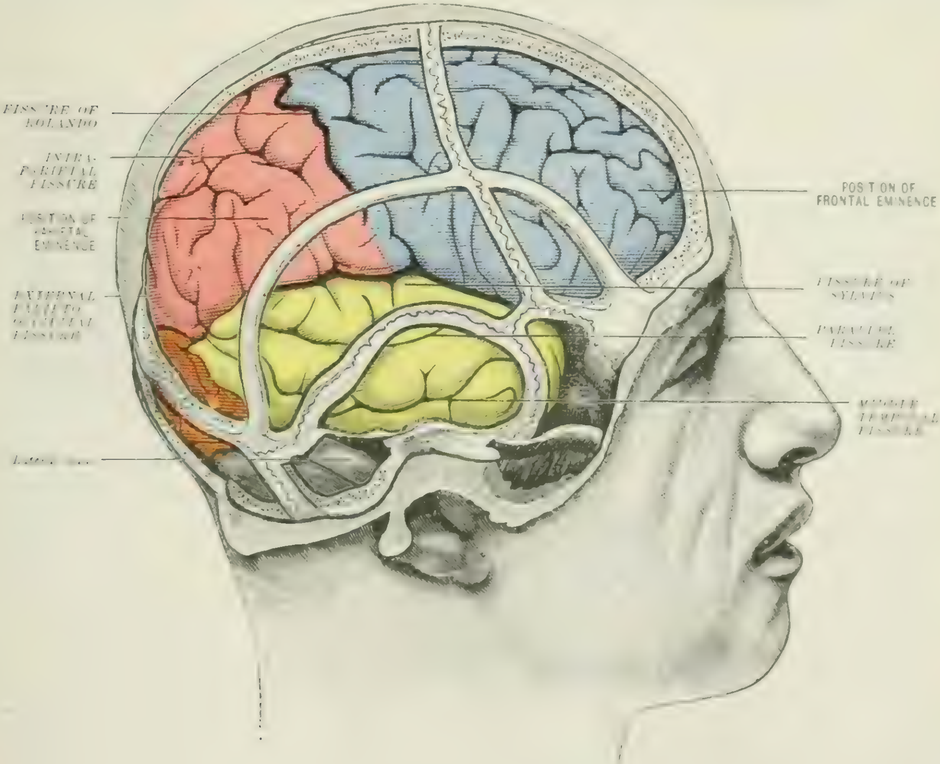
The position of the chief sulci will now be given:

Sylvian fissure (figs. 664 and 665).—The point of appearance of this, on the outer side of the brain, practically corresponds to the pterion (fig. 659)—a point which lies in the temporal fossa, about an inch and a half behind the external angular process and about the same distance above the zygoma. From this point the Sylvian fissure, which here separates the frontal and parietal from the temporo-sphenoidal lobe, runs backwards and upwards, ascending gently, at first in the line of the squamo-parietal suture, then crossing this suture about its centre, and thence, ascending more rapidly, it climbs up to the temporal ridge, to end three-quarters of an inch below the parietal eminence. Its termination is surrounded by the supramarginal convolution, to which the parietal eminence corresponds with sufficient accuracy. Such being the surface-marking of the chief or posterior horizontal limb of the fissure of Sylvius (s^3, fig. 664), it remains to indicate briefly the two shorter limbs which bound the inferior frontal convolution, which, on the left side, contains the centre for speech (Broca's convolution). Of these, the anterior horizontal (s^1, fig. 664) runs forwards across the termination of the coronal, just above the line of the spheno-parietal suture. The ascending limb (s^2, fig.

664) runs upwards for about an inch just behind the termination of the coronal suture, or two inches behind the external angular process. To indicate the fissure of Sylvius, a line should be drawn from a point corresponding to the pterion (p. 1081, fig. 659) backwards, at first gently and then more abruptly upwards, to one three-quarters of an inch below the parietal eminence. The ascending limb will start from a point two inches behind and slightly above the external angular process, and more obliquely forwards and upwards for about an inch.

Fissure of Rolando.—This most important fissure, around which the motor area is grouped, runs downwards and forwards, separating the frontal and parietal lobes between the following points: The upper end of the fissure, **the upper Rolandic point,** will be found about half an inch behind the centre of the sagittal line (p. 1090)—a line drawn from just below the glabella to the external occipital protuberance. On the skull, this upper Rolandic point will be nearly two inches behind the bregma. The lower extremity of the fissure, **inferior Rolandic point,** would be about half an inch above the Sylvian line and one inch behind the Sylvian point (fig. 666). Owing to the obliquity of the fissure of Rolando, this lower point will be nearer the coronal suture than the upper, being distant from it about one inch. A line drawn between the upper and lower Rolandic points (the Rolandic line) will give the direction of the fissure of Rolando with sufficient accuracy, when the two genua, the upper concave and the lower convex forwards (fig. 664) are allowed for. The Rolandic line forms with the sagittal line an angle anteriorly of 65° to 70°: if prolonged downwards and forwards to the zygoma, the line would reach this process about its centre (Le Fort).

FIG. 665.—DRAWING OF A CAST OF THE HEAD OF AN ADULT MALE.
(Prepared by Professor Cunningham to illustrate cranio-cerebral topography.)



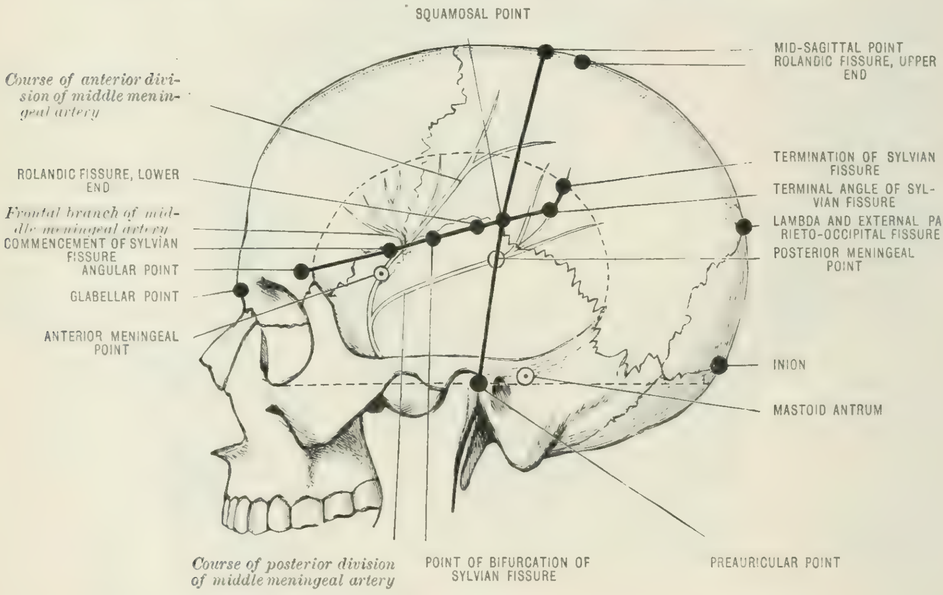
To find the fissure of Rolando the following methods have been employed. In a given case it is well to employ them all, so that any error in one may be checked by another measurement:

I. The upper and lower Rolandic points are found as above directed, and the Rolandic line is drawn between them.

II. The upper Rolandic point is taken two inches behind the bregma, or junction of the coronal and sagittal sutures. The position of the lower end of the fissure is thus determined: From the very end of the external orbital process, where this rises up to join the temporal crest, draw a horizontal line two and a quarter inches long, and from the extreme end of this draw a vertical line of a little over one inch. Between these upper and lower Rolandic points, passing rather obliquely forwards, lies the fissure of Rolando (Lucas, Championnière).

III. Here (1) the sagittal line is taken; (2) and (3) at a right angle to this two lines are drawn vertically over the side of the skull,—the one starting from the pre-auricular point (fig. 666), the other at the level of the posterior border of the mastoid process,—and meeting the sagittal line about two inches behind the second; (4) from the junction of the lines 1 and 3, one is drawn diagonally downwards, reaching 2 about two inches above and a little in front of the external auditory meatus (Reid and Godlee).

FIG. 666.—CRANIO-CEREBRAL TOPOGRAPHY. (Anderson and Makins.)


SQUAMOSAL POINT
MID-SAGITTAL POINT
ROLANDIC FISSURE, UPPER END
Course of anterior division of middle meningeal artery
TERMINATION OF SYLVIAN FISSURE
ROLANDIC FISSURE, LOWER END
TERMINAL ANGLE OF SYLVIAN FISSURE
Frontal branch of middle meningeal artery
LAMBDA AND EXTERNAL PARIETO-OCCIPITAL FISSURE
COMMENCEMENT OF SYLVIAN FISSURE
POSTERIOR MENINGEAL POINT
ANGULAR POINT
GLABELLAR POINT
ANTERIOR MENINGEAL POINT
INION
MASTOID ANTRUM
Course of posterior division of middle meningeal artery
POINT OF BIFURCATION OF SYLVIAN FISSURE
PREAURICULAR POINT

IV. The fissure of Rolando may be found by the measurements given by Makins and Anderson (fig. 666).

The **external parieto-occipital fissures.**—The upper end of this will appear just in front of the lambda.

Before leaving this subject, the attention of the student and surgeon is drawn to fig. 666 and the method which it illustrates—that of Anderson and Makins. As claimed by these surgeons and anatomists, their method fulfils the requirements of any practical scheme of cranio-cerebral topography, viz.: (1) The cranial landmarks employed shall be distinct, and subject as little as possible to variations in relation to the general proportions of the skull-cap; (2) that the guiding lines, drawn by the aid of these landmarks, shall adapt themselves to skulls of varying size and conformation; and (3) that no special apparatus shall be required for the localisation.

The method recommended by Anderson and Makins is the following: The cranial landmarks (fig. 666) are (1) the **glabellar point**, in the midline of the nasal eminence, on a level with the upper margin of the orbits; (2) the **inial point**, corresponding to the external occipital protuberance; (3) the **mid-sagittal point**, midway between these; (4) the **pre-auricular point**, in front of the tragus, on a level with the upper border of the external auditory meatus; (5) the **angular point**, over the external angular process, on a level with the upper border of the orbit; (6) the **squamosal point**, at the junction of the middle and lower thirds of the line (Frontal line) between the pre-auricular and mid-sagittal points. By the aid of these points, **three lines** may be drawn upon the shaven scalp definitely related to the principal fissures of the outer surface of the brain: (1) The **sagittal line**, from the glabella to the inion; with this line coincides the longitudinal fissure. (2) The **squamosal line**, from the angular to the squamosal point, and about two inches beyond; in this line and its continuation lies the fissure of Sylvius. (3) The **frontal line**, from the pre-auricular to the mid-sagittal point. The fissure of Rolando crosses this line at an acute angle. Its upper end, carried to the midline, lies three-eighths of an inch behind the mid-sagittal point; its lower end, in the squamosal line, three-eighths of an inch beyond the squamosal point.

THE FACE

The outline of the different bones—nasal, upper and lower jaws, malar, and zygoma—can be readily traced.

Arteries.—The **supraorbital artery** can be felt beating just above its notch (junction of inner with outer two-thirds of supraorbital arch); the **temporal** itself can be felt where it crosses the root of the zygoma just in front of the tragus, its anterior branch about an inch and a quarter above and behind the external angular process of the frontal; the **occipital** (p. 1102) pulsates near the middle of a line drawn from the occipital protuberance to the mastoid process; the **posterior auricular** behind the apex of the mastoid. The **external carotid** lies behind the ascending ramus of the jaw. The **facial** (fig. 667) crosses the jaw just in front of the masseter; if divided, both ends must be secured here. It can be felt again a little behind the angle of the mouth, just beneath the mucous membrane (it here gives off the coronaries, which can also be felt, lying deeply, if the lip is taken between the finger and thumb); and again by the side of the nose, as it runs up to the tendo oculi. To trace the course of the facial artery a line should be drawn from a point a little above and outside the tip of the great cornu of the hyoid to the lower part of the anterior border of the masseter, and thence to one outside and above the angle of the mouth, and so onwards, external to the angle of the nose, up to the inner canthus. The little **frontal artery** is of importance, as it nourishes the flap when a new nose is taken from the forehead.

A line drawn from the tip of the lobule of the ear to a point midway between the nose and upper lip gives the level of the **parotid duct**, which opens into the mouth opposite the second upper molar tooth. The level of the duct would be about a finger's breadth below the zygoma. It is accompanied by the transverse facial artery above, and the infraorbital branch of the facial nerve below. The **sheath of the parotid**, continuous with those of the masseter and sterno-mastoid, is strong enough to cause most exquisitely painful tension when inflammation of the gland is present.

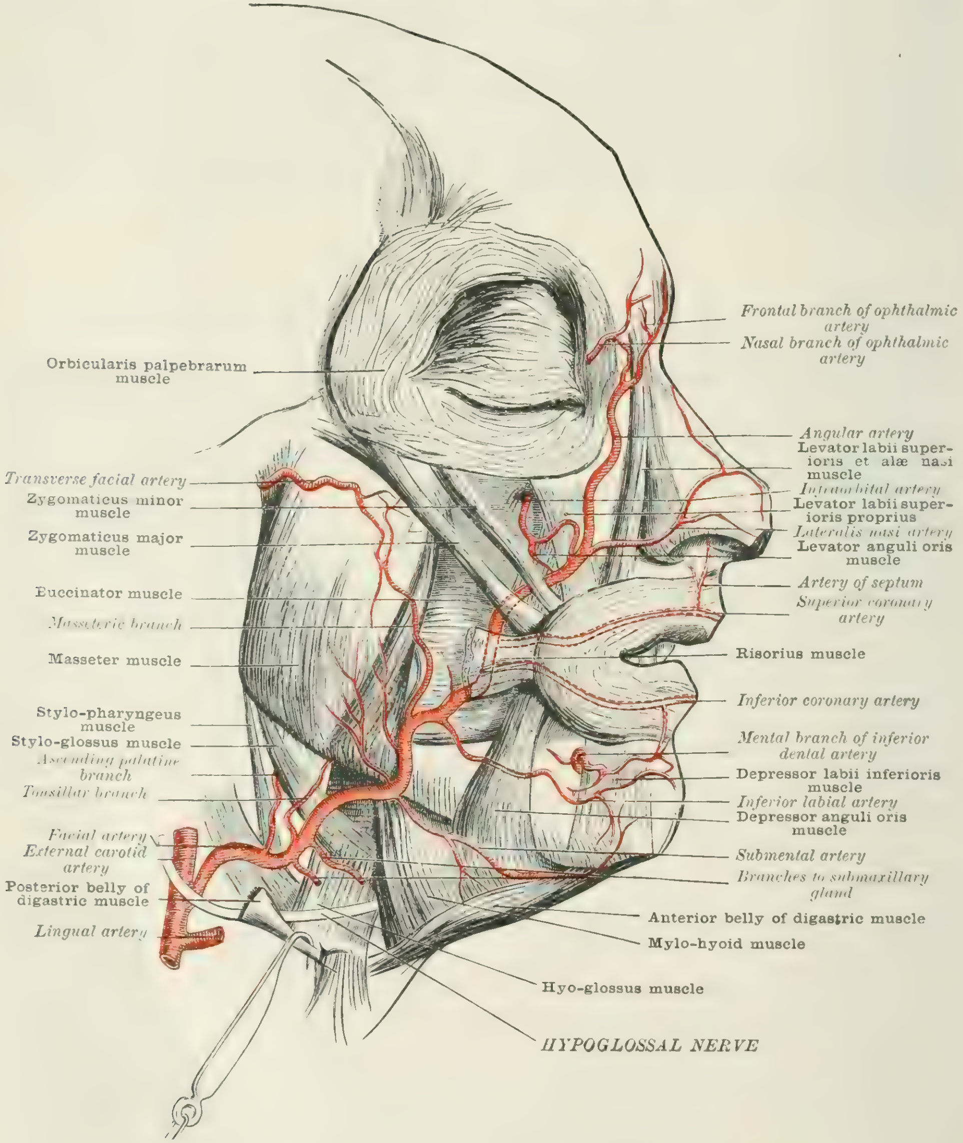
The parotid region would be thus mapped out (fig. 670). *Above* by the posterior two-thirds of the zygoma, *below* by a line corresponding to the posterior belly of the digastric (fig. 670); *behind* are the external auditory meatus, mastoid, and sternomastoid. *In front* the gland and socia parotidis overlap the posterior part of the masseter, to a variable degree (fig. 670).

The proximity of the parotid to the styloid process, to which the pharynx is attached, accounts for deep parotid abscess opening into the pharynx. Below the root of the zygoma, when this process is traced backwards, will be felt the temporo-mandibular joint; and when the mouth is opened, the condyle will be felt to glide forwards upon the eminentia articularis.

THE EYELIDS AND LACHRYMAL APPARATUS

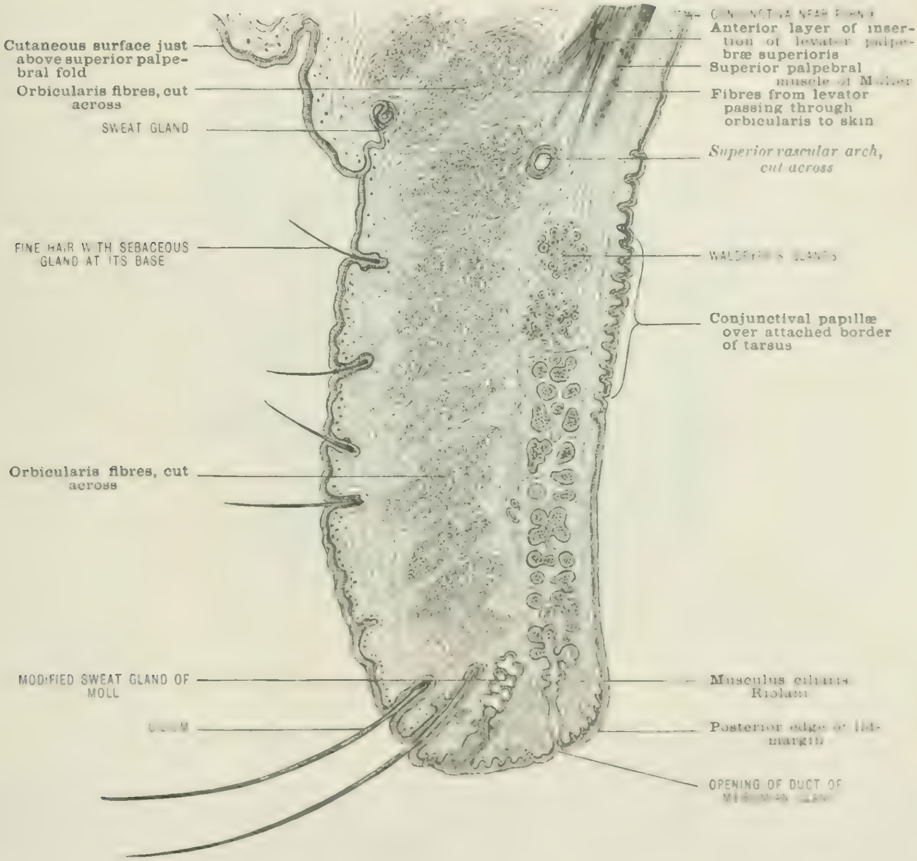
The structure of the lids.—The different layers are of much practical importance. (1) The **skin** is delicate and fatless, and contains pigment, the object of this being to protect the eye from bright light. It helps to explain the 'dark circles' of later life. (2) **Areolar tissue.** Owing to its looseness and delicacy, this is very liable to infiltration, as in ascites and erysipelas. (3) **Orbicularis.** Paralysis of this, the palpebral portion, leads to epiphora, the puncta being no longer kept applied against the eye. (4) **Palpebral ligament,** reaching from the orbit to the tarsal cartilage. This is usually strong enough to prevent hæmorrhage, due to fractured base of skull, becoming subcutaneous. (5) **Levator palpebræ.** (6) **Tarsal cartilage**; in reality, densely felted fibrous tissue. (7) **Meibomian**

Fig. 667.—Scheme of the Facial Artery.


Frontal branch of ophthalmic artery
Nasal branch of ophthalmic artery
Orbicularis palpebrarum muscle
Angular artery
Levator labii superioris et alæ nasi muscle
Transverse facial artery
Infraorbital artery
Zygomaticus minor muscle
Levator labii superioris proprius
Lateralis nasi artery
Zygomaticus major muscle
Levator anguli oris muscle
Artery of septum
Buccinator muscle
Superior coronary artery
Masseteric branch
Risorius muscle
Masseter muscle
Inferior coronary artery
Stylo-pharyngeus muscle
Stylo-glossus muscle
Mental branch of inferior dental artery
Ascending palatine branch
Depressor labii inferioris muscle
Tonsillar branch
Inferior labial artery
Depressor anguli oris muscle
Facial artery
External carotid artery
Submental artery
Branches to submaxillary gland
Posterior belly of digastric muscle
Anterior belly of digastric muscle
Lingual artery
Mylo-hyoid muscle
Hyo-glossus muscle
HYPOGLOSSAL NERVE

glands, lashes, and **sebaceous follicles.** Localised inflammation starting in any of these three structures, especially the last, will cause a 'stye.' The frequency with which the lid-border is the seat of that most troublesome chronic inflammation, blepharitis, and its result 'blear eye,' is explained by these anatomical points. Its circulation is terminal and slow; half skin and half mucous membrane, it is moister and more liable to local irritation than the skin; while its numerous glands readily participate in any inflammation. (8) **The conjunctiva.** To trace this important membrane, the lids should be everted, when the following will be noted. The conjunctiva over the tarsal part of the lid is closely adherent, and through it, a series of nearly straight, parallel, light yellow lines and granules, the Meibomian glands, can be seen. Beyond the tarsi, the conjunctiva, now palpebral, is thicker and freely movable, owing to the abundant submucous tissue. Numerous underlying vessels are visible here. Tracing the conjunctiva onwards over the sclerotic, the former becomes thinner and contains very few vessels, any present still moving with it (conjunctival). Occasional vessels seen through the sclerotic conjunctiva are attached to the sclerotic itself (anterior ciliary). At the junction of the palpebral and sclerotic conjunctivæ is the reflexion called the fornix. On this reflexion in the upper lid open the lachrymal ducts. Traced onwards over the cornea, the conjunctiva becomes thinned down to a mere epithelial layer, closely adherent to the subjacent parts.

FIG. 668.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER EYELID. (After Waldeyer and Fuchs.)


Cutaneous surface just above superior palpebral fold
Orbicularis fibres, cut across
SWEAT GLAND
FINE HAIR WITH SEBACEOUS GLAND AT ITS BASE
Orbicularis fibres, cut across
MODIFIED SWEAT GLAND OF MOLL
CILIUM
CONJUNCTIVA NEAR FORNIX
Anterior layer of insertion of levator palpebræ superioris
Superior palpebral muscle of Müller
Fibres from levator passing through orbicularis to skin
Superior vascular arch, cut across
WALDEYER'S GLANDS
Conjunctival papillæ over attached border of tarsus
Musculus ciliaris Riolani
Posterior edge of lid-margin
OPENING OF DUCT OF MEIBOMIAN GLAND

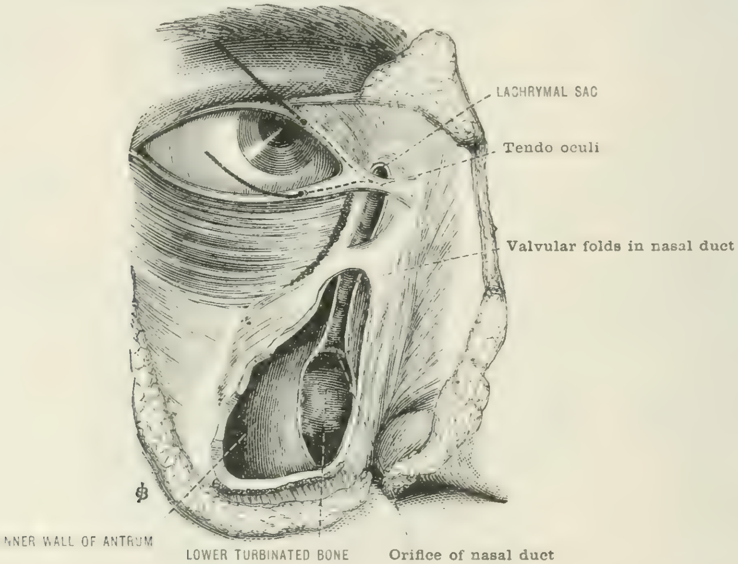
The differing structure of the palpebral and ocular portion has important bearings. Thus the palpebral is thick, highly vascular, and very sensitive. To this vascularity we owe the chemosis, or hot, red, tense swelling of purulent ophthalmia. The exquisite suffering of the same disease, or that caused by a foreign body, is explained by the numerous nerve-papillæ. To the thickness and abundance of the connective tissue are due the contraction and permanent thickening which may occur in granular lids. The so-called granulations, met with in this disease on the palpebral conjunctiva, are really little nodules of hypertrophied lymphoid follicles, or mucous glands, which abound here.

The **position of the lachrymal puncta** should be noted: owing to their backward direction, the lids must be previously everted. The puncta are kept open by a minute fibrous ring.

Each is situated on a minute papilla at the junction of the inner and straight third of the lid with the outer curved two-thirds. Close to the inner canthus, in addition to the puncta and papillæ, should be noted the caruncula lachrymalis, with its delicate hairs, and the plica semilunaris, which corresponds to the third eyelid of certain birds.

FIG. 669.—THE LACHRYMAL APPARATUS AND NASAL DUCT. (Bellamy.)

(Bristles are introduced into the puncta lachrymalia.)



The **lachrymal sac** is the most important of the lachrymal apparatus, from its disfiguring diseases; it lies in a bony groove, between the nasal process of the maxilla and the lachrymal bone. The tendo oculi crosses it a little above its centre (fig. 669). Thus two-thirds of the sac are below the tendon, and in suppuration the opening is made below it also. The angular artery ascends on the nasal side of the sac. The **manipulation of a probe along the lachrymal passages** should thus be practised:—The lower lid being drawn outwards and downwards by the thumb, the probe is passed vertically into the punctum, then turned horizontally and passed on till it reaches the inner wall of the sac. It is then raised vertically, and pushed steadily along the duct downwards, and a little outwards and backwards, till the floor of the nose is reached.

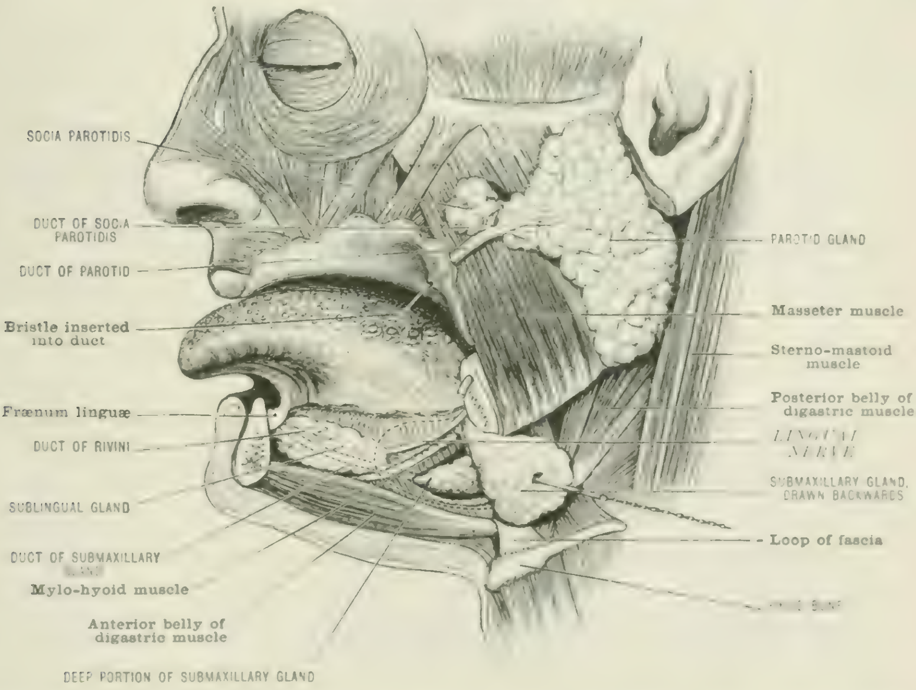
If the eyes are opened naturally, the greater part of the cornea, behind it the iris, with the pupil in the centre, on either side of the cornea some of the sclerotic, the semilunar fold and caruncle can be seen.

THE MOUTH

On the floor, in the centre, is the frænum linguæ. In dividing the **frænum** for tongue-tie, the scissors should be kept close to the bone, so as to avoid the ranine vessels. Of these, the ranine vein can be seen beneath the mucous membrane; the artery lies close to it, but deeper.

The orifices of Wharton's duct open on minute papillæ situated at the ends of ridges of mucous membrane which curve forwards and inwards to meet in the middle line a little behind the symphysis of the jaw, on either side of the frænum linguæ (fig. 670). Together with Wharton's duct, or close to it, opens the duct of Bartholin, or chief duct of the **sublingual gland.** If the above folds be traced backwards they correspond, as they diverge, to the ranine veins, and, more deeply, to Wharton's duct and the lingual nerve (fig. 670). Under these ridges lie the sublingual glands, the majority of whose ducts open on the surface of the folds. Dilatation of one of these Rivinian ducts, more frequently dilatation of a muciparous gland,—and much more rarely dilatation of Wharton's duct,—constitutes a 'ranula.' The **submaxillary gland** can be felt nearer the angle of the jaw lying between its fossa and the mucous membrane, especially if pressure is made from outside. The attachment of the **genio-hyo-glossi** can be felt behind the symphysis: the division of the muscles allows the tongue to come well out of the mouth; but when both have to be divided, the tongue loses much of its steadiness, and may easily fall back over the larynx during the administration of the anæsthetic or, later on, in sleep. It should therefore be secured forwards for a while with silk. While the mouth is widely open, the pterygo-mandibular ligament can be seen and felt beneath the mucous membrane, behind the last molar tooth. Just below and in front of the lower attachment of this ligament, the **lingual nerve** can be felt lying close to the bone below the last molar. It can be divided here to give relief from pain in incurable cancer of the tongue, at a point where it crosses a line

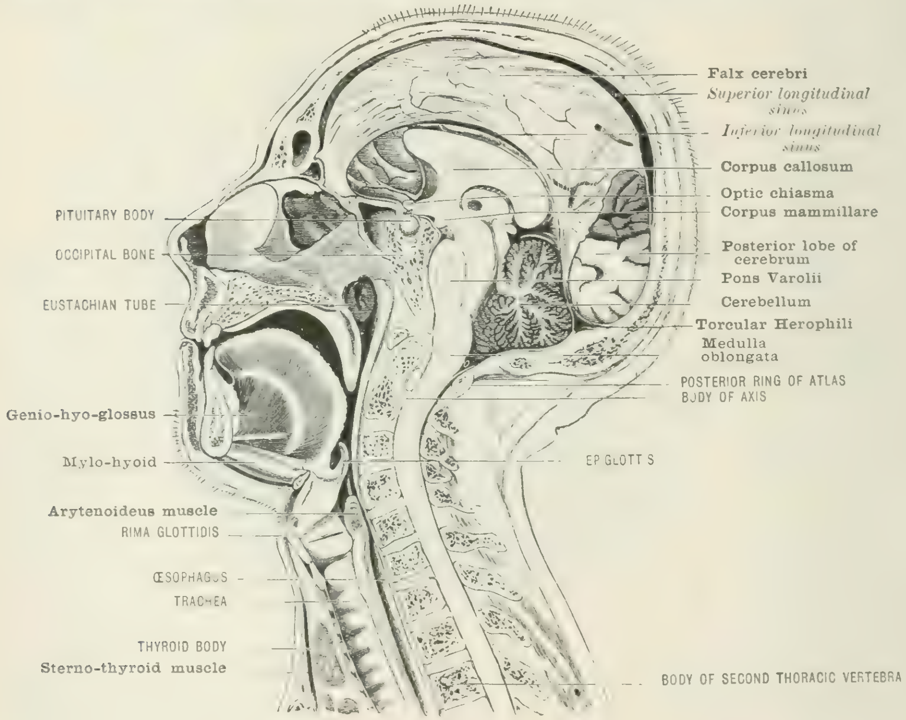
FIG. 670.—SIDE OF THE FACE AND MOUTH CAVITY, SHOWING THE THREE SALIVARY GLANDS.


SOCIA PAROTIDIS
DUCT OF SOCIA PAROTIDIS
DUCT OF PAROTID
Bristle inserted into duct
Frænum linguæ
DUCT OF RIVINI
SUBLINGUAL GLAND
DUCT OF SUBMAXILLARY GLAND
Mylo-hyoid muscle
Anterior belly of digastric muscle
DEEP PORTION OF SUBMAXILLARY GLAND
PAROTID GLAND
Masseter muscle
Sterno-mastoid muscle
Posterior belly of digastric muscle
LINGUAL NERVE
SUBMAXILLARY GLAND, DRAWN BACKWARDS
Loop of fascia
HYOID BONE

drawn from the last molar tooth to the angle of the jaw, by entering a knife nearly three-quarters of an inch behind and below the tooth, and cutting towards it on the bone (Moore). Another and far simpler and surer method is to draw the tongue out of the mouth and expose the nerve where it lies superficially under the mucous membrane thus made prominent between the side of the tongue and gums, the centre of the incision being opposite to the last molar tooth (Roser, Létiévant).

Behind the last molar tooth can be felt the **coronoid process,** and higher up, just behind and inside the tooth, the **hamular process of the sphenoid.** This process is a landmark to the site of the posterior palatine canal, which lies just in front of it, and which transmits the posterior and descending palatine branch of the internal maxillary, together with the anterior or great palatine nerve. The vessel and nerve run forwards in grooves towards the anterior palatine canal, and their position must be remembered in raising the flaps during the operation for closure of a cleft in the hard palate. To ensure the vitality of the flaps the incisions must be made close to and parallel with the upper alveolus.

Fig. 671.—Section of the Skull and Brain in the Median Plane. (Braune.)


Falx cerebri
Superior longitudinal sinus
Inferior longitudinal sinus
Corpus callosum
Optic chiasma
Corpus mammillare
Posterior lobe of cerebrum
Pons Varolii
Cerebellum
Torcular Herophili
Medulla oblongata
POSTERIOR RING OF ATLAS
BODY OF AXIS
PITUITARY BODY
OCCIPITAL BONE
EUSTACHIAN TUBE
Genio-hyo-glossus
Mylo-hyoid
EPIGLOTTIS
Arytenoideus muscle
RIMA GLOTTIDIS
ŒSOPHAGUS
TRACHEA
THYROID BODY
Sterno-thyroid muscle
BODY OF SECOND THORACIC VERTEBRA

On the inner side of the coronoid, between it and the tuberosity of the upper jaw, is a recess where a temporal abscess will point, having travelled down under the fascia and zygoma. When a patient breathes deeply through the mouth, and the head is thrown back, the soft palate is raised, the pillars are separated, and the uvula and fauces, with the anterior and posterior pillars, the tonsils, and the back of the pharynx are exposed. This portion of the pharyngeal mucous membrane would lie over the lower part of the second and the upper part of the third cervical vertebræ, the anterior arch of the atlas corresponding to the level of the posterior nares, and the body of the axis to the level of the soft palate (fig. 671). If a finger be introduced past the soft palate to this part of the spine and turned upwards and downwards, it is possible to examine the upper four or five and, in children, six vertebræ, as far as the anterior surfaces of their bodies. 'The part of the column which is accessible to a straight instrument introduced through the mouth is very limited, extending, in the adult, from the lower border of the axis to the middle or lower part of the fourth cervical vertebra; in the child, owing to the small size of the face, it comprises the bodies of the axis and of the third cervical vertebra." (Thane and Godlee, from Chipault.)

TONSILS.—The **relations of the tonsils** should be carefully examined. Thus, they are separated externally by the superior constrictor and pharyngeal aponeurosis from the ascending pharyngeal and internal carotid arteries. The extent to which the tonsil is covered by the anterior pillar, how far it projects upwards beneath the soft palate or downwards into the pharynx, have all important bearings on the mode of removal. Its position corresponds to the angle of the jaw. When serious hæmorrhage follows operations on the tonsils, it usually comes from one of the numerous tonsillar arteries, which is enlarged, and not from the ascending pharyngeal or internal carotid.

The **finger introduced downwards at the back of the mouth,** especially if the parts are rendered insensitive by cocaine, feels the circumvallate papillæ, the lingual and laryngeal surfaces of the epiglottis, the aryteno-epiglottidean folds, with the cartilages of Wrisberg and Santorini. **If the finger be moved upwards** behind the soft palate and turned upwards to the base of the skull, and then forwards, it will impinge on the posterior nares, separated by the vomer, and, within each nostril, the hinder end of the inferior and middle spongy bones; above and behind is felt the basilar process of the skull, the vault of pharynx, and upper cervical spine (fig. 671).

The **size of the nares,** one inch by half an inch, and the presence of any adenoids, are especially to be noted. The **richness of the naso-pharynx in glandular structures,** its proneness to inflammation, and of this inflammation to spread to other parts,—e.g. the tympanum,—are well known. The finger should be familiar with the feel of adenoids—i.e. hypertrophied post-nasal lymphatic nodules—soft bodies of irregular shape blocking up the naso-pharynx. To make out how far this is the case, it is well to take the nasal septum as the starting-point.

THE PALATE

Between the diverging pillars of the soft palate is the **isthmus faucium,** bounded above by the free margin of the palate, and below by the dorsum of the tongue. Of its lateral boundaries, the posterior pillars come nearer each other than the anterior. **In paring the edges of a cleft soft palate, the following structures would be, successively, cut through :** (1) Oral mucous membrane; (2) submucous tissue, with vessels, nerves, and glands; (3) palato-glossus muscle; (4) aponeurosis of tensor palati; (5) anterior fasciculus of palato-pharyngeus; (6) levator palati and azygos uvulæ muscles; (7) posterior fasciculus of palato-pharyngeus; (8) submucous tissue, vessels, nerves, and glands; (9) posterior mucous membrane. The soft palate is thicker than it seems, the average in an adult being a quarter of an inch. The muscles widening a cleft are the tensor and levator, while the superior constrictor closes it in swallowing. Of the arteries to the palate, the largest is the descending palatine branch of the internal maxillary. This emerges from the posterior palatine canal close to the inner side of the last molar tooth, and runs forward to supply the hard palate (page 496).

THE NOSE

On the face the outline of the nasal bones can be easily traced, and below them the upper lateral cartilages, flat and also somewhat triangular. Below these are the lower lateral cartilages, curved and so folded back that each forms an outer and an inner plate. Of these the inner meet below the septal cartilage to form the tip of the nose, while the outer curve backwards, and, together with dense masses of cellular tissue and fat and accessory cartilages, form the alæ.

With the speculum, especially if the head be thrown back and the tip of the nose drawn up, the lower part of the septum, floor of the nose, and greater

FIG. 672.—SECTION OF THE NOSE, SHOWING THE TURBINAL BONES AND MEATUSES, WITH THE OPENINGS IN DOTTED OUTLINE.

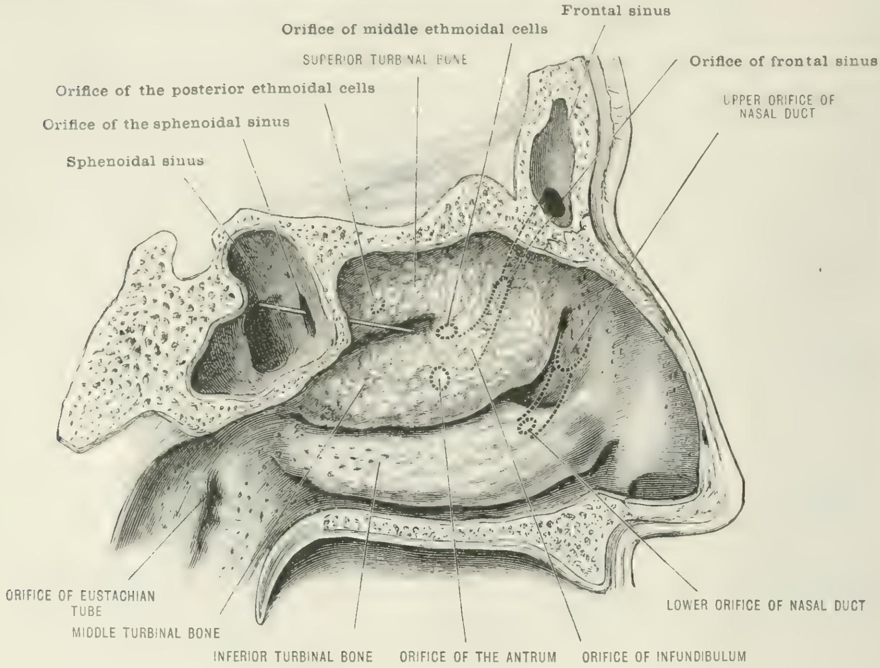
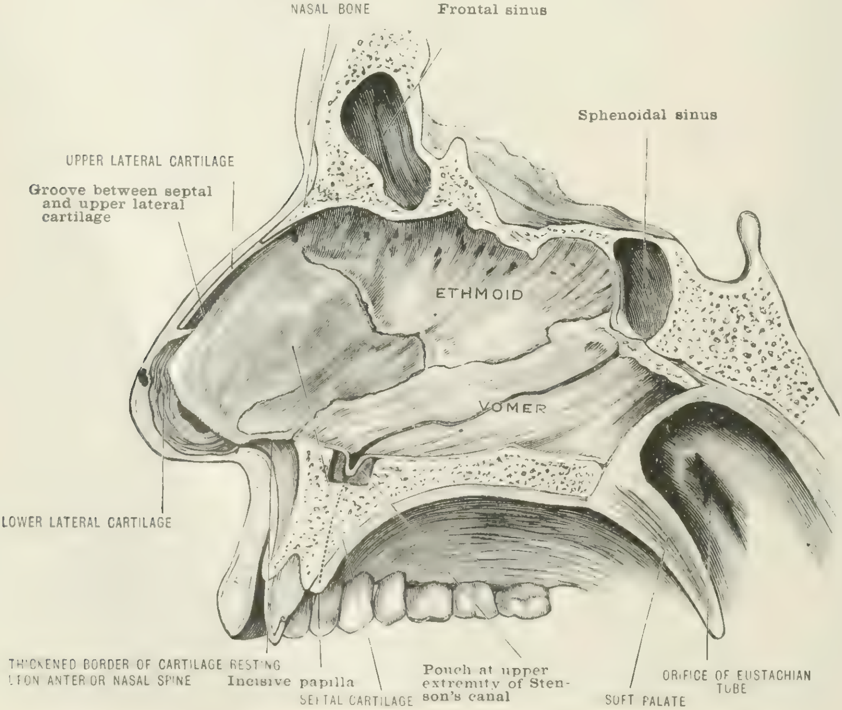

Frontal sinus
Orifice of middle ethmoidal cells
SUPERIOR TURBINAL BONE
Orifice of frontal sinus
Orifice of the posterior ethmoidal cells
UPPER ORIFICE OF NASAL DUCT
Orifice of the sphenoidal sinus
Sphenoidal sinus
ORIFICE OF EUSTACHIAN TUBE
MIDDLE TURBINAL BONE
LOWER ORIFICE OF NASAL DUCT
INFERIOR TURBINAL BONE
ORIFICE OF THE ANTRUM
ORIFICE OF INFUNDIBULUM

FIG. 673.—SECTION SHOWING BONY AND CARTILAGINOUS SEPTUM.

The dotted line indicates the course of the anterior palatine canal.


NASAL BONE
Frontal sinus
Sphenoidal sinus
UPPER LATERAL CARTILAGE
Groove between septal and upper lateral cartilage
ETHMOID
VOMER
LOWER LATERAL CARTILAGE
THICKENED BORDER OF CARTILAGE RESTING UPON ANTERIOR NASAL SPINE
Incisive papilla
SEPTAL CARTILAGE
Pouch at upper extremity of Stenson's canal
SOFT PALATE
ORIFICE OF EUSTACHIAN TUBE

portion of the inferior turbinated bone can be seen. On throwing the head further back, with a good light the lower margin of the middle turbinated bone can also be made out. This is much higher up and nearly on a level with the root of the nasal bone. The septum often deviates to one side. The mucous membrane over it is, in health, dull red in colour; that over the inferior turbinated is thicker. The anterior extremity of the latter bone is about three-quarters of an inch behind the orifice, while the opening of the nasal duct is about one inch behind and about three-quarters of an inch above the floor. The opening into the antrum is situated in about the centre of the middle meatus and one inch above the floor.

The posterior nares should be examined by the finger passed behind the soft palate. Each oval aperture measures, in the adult skull, about half an inch transversely by one vertically. In life the above dimensions are somewhat less, owing to the presence of the mucous membrane. The boundaries of these apertures should be identified, viz.: internally, the vomer; externally, the internal pterygoid plate and palate bone; above, the basisphenoid; and below, the posterior border of the horizontal plates of the palate bones and posterior nasal spine.

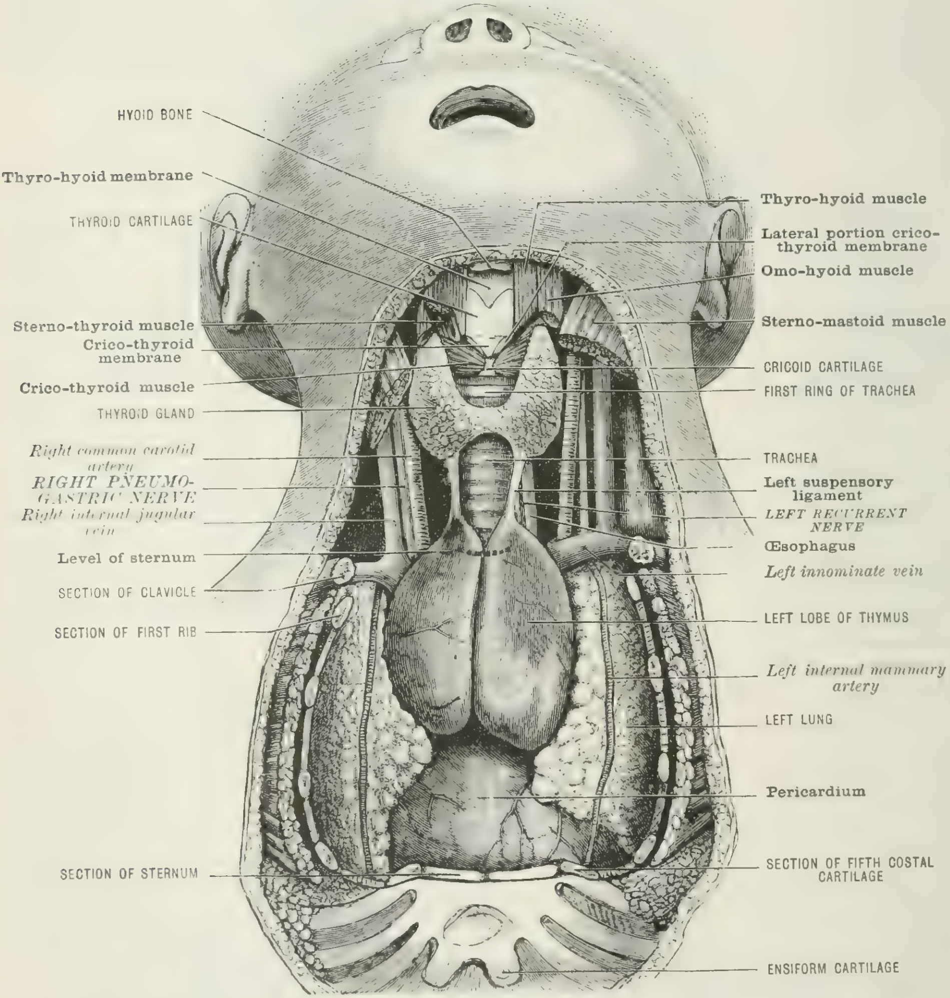
THE NECK

Landmarks in the middle line.—Passing from the symphysis to the supraclavicular notch is the body of the hyoid, which is nearly on a level with the angles of the jaw. On either side of the body are the great cornua. The upper borders of these are the guides to the lingual arteries. Below the hyoid is the thyrohyoid space, which corresponds with the epiglottis and the upper aperture of the larynx. Thus, if the throat be cut above the hyoid, the mouth will be opened and the tongue cut into; if the thyro-hyoid space be cut, the pharynx would be opened and the epiglottis wounded near its base. Behind the centre of the anterior margin of the thyroid is the rima glottidis. The projection of the thyroid notch is much more distinct in men than in women or children. It does not appear before puberty, and thus flatness of the thyroid must be expected when the landmarks for tracheotomy are sought for in children with short fat necks. The cricoid, on the other hand, is always to be made out. It corresponds in horizontal plane to the following:—(1) The fifth cervical vertebra. (2) The junction of pharynx and œsophagus; from the narrowing of the tube here, foreign bodies may lodge at this point and cause dyspnœa by pressing on the air-tube in front. The cricoid is taken as the centre of the incision in œsophagotomy, and also for ligature of the common carotid. (3) The junction of larynx and trachea. (4) The crossing of the omohyoid over the common carotid. (5) The middle cervical ganglion.

The distance between the cricoid and the manubrium is only about an inch and a half. When the neck is stretched, about three-quarters of an inch more is gained. Thus, as a rule, there are not more than seven or eight tracheal rings above the sternum. Of these, the second, third, and fourth are covered by the thyroid isthmus. The parts met with in the middle line—(*a*) above, and (*b*) below the isthmus—should be borne in mind: (*a*) Skin, superficial fascia, branches of transverse cervical and infra-mandibular nerves, lymphatics, cutaneous arteries, anterior jugular veins—with their transverse branches smaller above,—deep fascia, sternohyoids, cellular tissue, superior thyroid vessels, and tracheal layer of deep fascia. The importance of this last is two-fold, as, first, the tube in tracheotomy may be passed between it and the trachea, and after a wound in this region this layer, continuous with the pericardium, may conduct discharges into the mediastina. (*b*) The surface structures are much the same, but the anterior jugular veins and their transverse branches are much larger. The inferior thyroid veins are also larger. A thyroidea ima may be present, and the innominate artery, which often crosses the trachea above the sterno-clavicular joint, may do so as high as the seventh tracheal ring. The trachea is also smaller, deeper, and less steadied by muscles. The thymus, too, in young children, may prove a difficulty. Thus, in children, the high operation, incising the cricoid and crico-tracheal membrane, if needful, is to be preferred.

The **sterno-mastoid** is the landmark for several important operations. Its inner border, the thicker and better marked of the two, overlaps the carotids; the common carotid corresponding, as far as the upper border of the thyroid, with a line drawn from the sterno-clavicular joint to midway between the mastoid process and the angle of the jaw. The artery can be best compressed above the level of the cricoid, as here it is less deeply covered. The transverse process of the sixth cervical vertebra is called the carotid tubercle, after Chassaignac, who advised compression of the carotid at this point. This process lies two to three inches above the clavicle. Compression below it will command the vertebral as well. The student should recall the deep relations of the sterno-mastoid, which he may classify as vessels, nerves, muscles, glands, and bones; or, according to their position, (1) those above the level of the angle of the jaw; (2) those between the angle of the jaw and the omo-hyoid; (3) those below the omo-hyoid.

FIG. 674.—THYMUS GLAND IN A CHILD AT BIRTH.


HYOID BONE
Thyro-hyoid membrane
THYROID CARTILAGE
Sterno-thyroid muscle
Crico-thyroid membrane
Crico-thyroid muscle
THYROID GLAND
Right common carotid artery
RIGHT PNEUMO-GASTRIC NERVE
Right internal jugular vein
Level of sternum
SECTION OF CLAVICLE
SECTION OF FIRST RIB
SECTION OF STERNUM
Thyro-hyoid muscle
Lateral portion crico-thyroid membrane
Omo-hyoid muscle
Sterno-mastoid muscle
CRICOID CARTILAGE
FIRST RING OF TRACHEA
TRACHEA
Left suspensory ligament
LEFT RECURRENT NERVE
Œsophagus
Left innominate vein
LEFT LOBE OF THYMUS
Left internal mammary artery
LEFT LUNG
Pericardium
SECTION OF FIFTH COSTAL CARTILAGE
ENSIFORM CARTILAGE

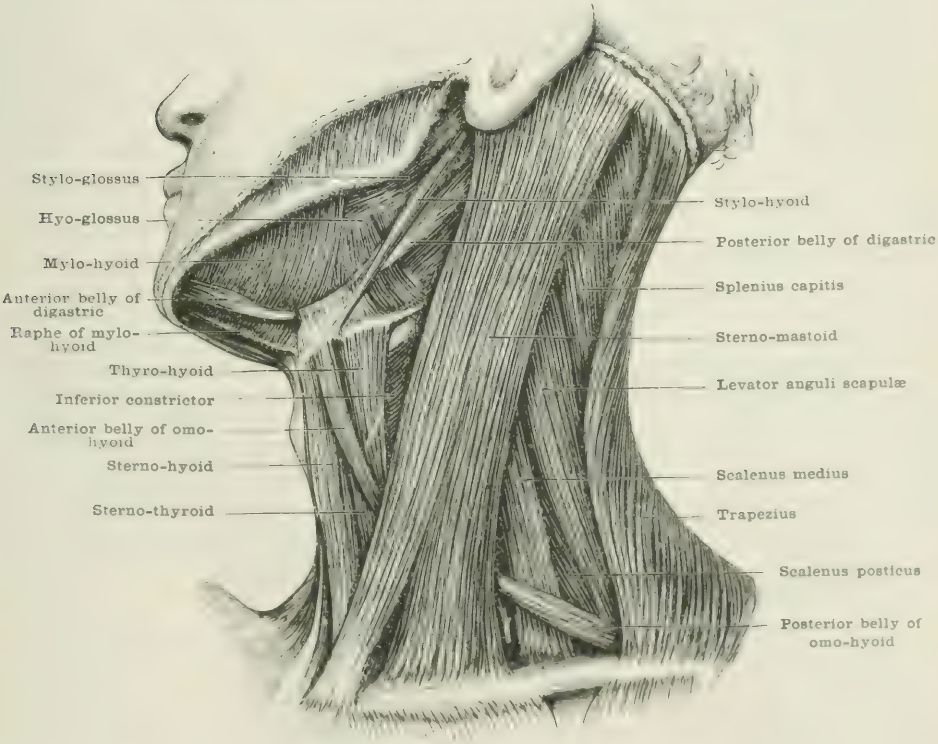
Of the two heads of the sterno-mastoid, the sternal is the thicker and more prominent, the clavicular the wider. A stab through the space (or interval) which lies between the two heads would wound the bifurcation of the innominate on the right side, and the common carotid on the left.

The position of the **anterior jugular,** curving outwards to pass beneath both origins of the muscle a little above the clavicle, and the external jugular, crossing at a varying level the outer border of the clavicular origin, must be remembered in such operations as tenotomy here. These veins are joined by numerous transverse branches, and become larger below.

The anterior jugular vein, commencing in the submaxillary region, descends a little to one side of the middle line. Just above the clavicle each vein turns outwards and, piercing the deep cervical fascia, passes under the sterno-mastoid, and opens into the external jugular or subclavian vein. It has no valves.

Behind the sterno-clavicular joint lies the commencement of the innominate veins, the bifurcation of the innominate artery on the right, and the common carotid artery on the left; deeper still lie the pleura and lung. The occasional high position of the innominate on the trachea may be a point of importance in tracheotomy, both at the time of the operation and later on, from the fatal facility with which a metal tube, if long retained after a low tracheotomy, may ulcerate into the vessel.

FIG. 675.—ANTERIOR AND LATERAL CERVICAL MUSCLES.


Stylo-glossus
Hyo-glossus
Mylo-hyoid
Anterior belly of digastric
Raphe of mylo-hyoid
Thyro-hyoid
Inferior constrictor
Anterior belly of omo-hyoid
Sterno-hyoid
Sterno-thyroid
Stylo-hyoid
Posterior belly of digastric
Splenius capitis
Sterno-mastoid
Levator anguli scapulæ
Scalenus medius
Trapezius
Scalenus posticus
Posterior belly of omo-hyoid

In front of the sterno-mastoid is the **anterior triangle**, which is **subdivided into three smaller triangles** by the digastric muscle above, and the anterior belly of the omo-hyoid below. These smaller triangles are called, from above, the submaxillary, the superior and inferior carotid triangles. The **submaxillary** or **supra-hyoid triangle** is bounded above by the jaw, and a line drawn back to the mastoid process; below, by the digastric and stylo-hyoid muscles; and in front by the middle line of the neck. This space contains the submaxillary gland, and embedded in the gland is the facial artery; deeper than the gland are the submental vessels and the mylo-hyoid vessels and nerve. Posteriorly, and separated from the above structures by the stylo-mandibular ligament, is the upper part of the external carotid artery which is embedded in the parotid gland, where it gives off its two terminal and the posterior auricular branches. More deeply lie the internal jugular vein, internal carotid artery, and the vagus.

The **superior carotid triangle** is bounded above by the digastric, below by the omo-hyoid, and behind by the sterno-mastoid. It contains the upper part of the common carotid and its branches, the external being somewhat anterior to the internal. All the branches of the external carotid, save the three just given, are found in this space, together with their veins, the internal jugular vein, the vagus and sympathetic nerves, and, for a short distance, the spinal accessory, together with those nerves which lie in front of and behind the carotids.

The **inferior carotid** or **tracheal triangle** is bounded above by the omo-hyoid, behind by the sterno-mastoid, and in front by the middle line of the neck. It contains the lower part of the carotid sheath and its contents, with, behind it, the inferior laryngeal nerve and inferior thyroid vessels, and to the inner side the trachea and thyroid gland.

The position of the **branches of the external carotid** should be remembered. The **superior thyroid,** arising just below the level of the great cornu of the hyoid bone, passes downwards and forwards to the back part of the thyroid cartilage and upper part of the thyroid body. Many of its branches are important in surgery. The **superior laryngeal** perforates the thyro-hyoid membrane. The **sterno-mastoid** passes outwards into the middle of the muscle, across the carotid sheath. The **crico-thyroid** crosses the space of the same name just below the lower border of the thyroid cartilage. The little **hyoid** branch runs to the lower border of the hyoid bone. The **lingual** artery arises from the parent trunk, opposite the tip of the great cornu of the hyoid, and passes forwards just above the great cornu, and thence to the side of the tongue. In the first part of its course, before it reaches the hyo-glossus, it is curved, at first ascending, and then, having ascended slightly, before it reaches the hyo-glossus, and while it lies under it, its curve is gentle, with the concavity upwards; beyond the hyo-glossus, as it lies on the muscles of the tongue beneath the mucous membrane, it is tortuous. The **lingual vein,** it will be remembered, does not run with its artery, but lies superficial to the hyo-glossus. It receives the two small venæ comites, which run with the lingual itself just before it crosses the common carotid. The line of the **facial artery** (fig. 667), which often arises with the lingual, has been given on page 1091. The **occipital artery** (fig. 667), starting on the same level as the facial (i.e. a point a little above and outside the tip of the great cornu of the hyoid bone), follows a line drawn upwards and outwards, first to the interval between the transverse process of the atlas and the mastoid process, the former bone being felt just below and in front of the tip of the latter; thence, lying in the occipital groove of the mastoid, the artery ascends gradually, enters the scalp, together with the great occipital nerve, at a point about midway between the external occipital prominence and the mastoid process, to follow, tortuously and superficial to the aponeurosis, the line of the lambdoid suture (p. 1088).

The surface-marking of the **digastric** and **omo-hyoid,** which subdivide the anterior triangle into the three smaller subtriangles above described, should be noted. The line of the **posterior belly of the digastric** corresponds to one drawn from the apex of the mastoid process to a point just above the junction of the great cornu and body of the hyoid bone; and from this spot, which gives the point of meeting of the two tendons, one slightly curving upwards to a point just behind the symphysis menti, would give that of the **anterior belly.**

To trace the **omo-hyoid,** a line should be drawn from the lower margin of the side of the hyoid bone obliquely downwards, so as to cross the common carotid opposite the cricoid cartilage, and thence curving outwards under the sterno-mastoid at the junction of its middle and lower thirds, and then onwards and still outwards, parallel with and a little above the clavicle, as far as its centre.

Posterior triangle.—This shows in its lower part a wide depression, the supraclavicular fossa. Here the brachial plexus may be felt, and, by pressure downwards and backwards, just outside the outer margin of the sterno-mastoid, the pulsation of the subclavian artery can be stopped against the first rib. This vessel curves upwards and outwards from behind the sterno-clavicular joint to disappear behind the centre of the clavicle, the highest point of the curve being half an inch to an inch above the bone. The artery on the left side lies more deeply than the right, and does not rise so high into the neck. The subclavian vein lies at a lower level and under cover of the clavicle. Into the above curve rise the pleura and lung.

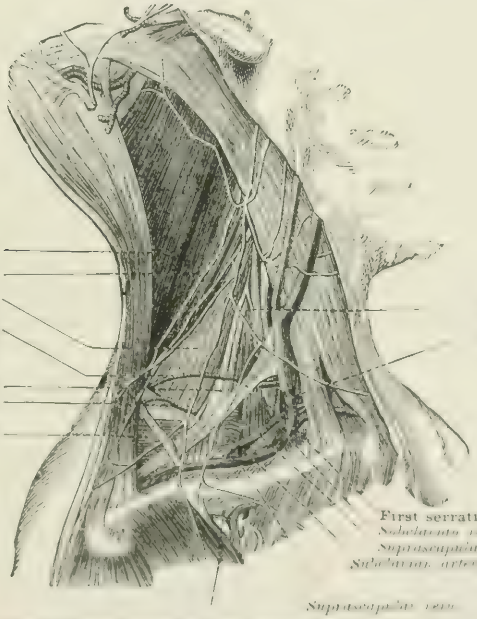
The **suprascapular** and **transverse cervical vessels** run outwards, parallel with the clavicle. The former lies behind the bone and subclavius; the latter also runs transversely outwards, across the root of the neck, but on a slightly higher plane, and thus a little above the clavicle.

Crossing the sterno-mastoid a little obliquely, in a line drawn from the angle of the jaw to the centre of the clavicle, runs the **external jugular vein.** About an inch and a half above the clavicle it perforates the deep cervical fascia, its coats being blended with the opening. The dilated part between this point and the subclavian vein is called the sinus, and is marked by two valves, neither of which is usually perfect. Just above the clavicle the posterior and suprascapular, transverse cervical, and a branch from the cephalic veins, form a plexus over the third part of the subclavian.

Opening into the external jugular, in the middle or lower third of its course, is the **posterior external jugular,** a vessel which begins in the occipital region superficially and runs down in front of the anterior border of the trapezius, across the posterior triangle.

FIG. 676.—REGION OF THE THIRD PART OF THE SUBCLAVIAN ARTERY. (Bellamy.)

(The shoulder represented depressed.)

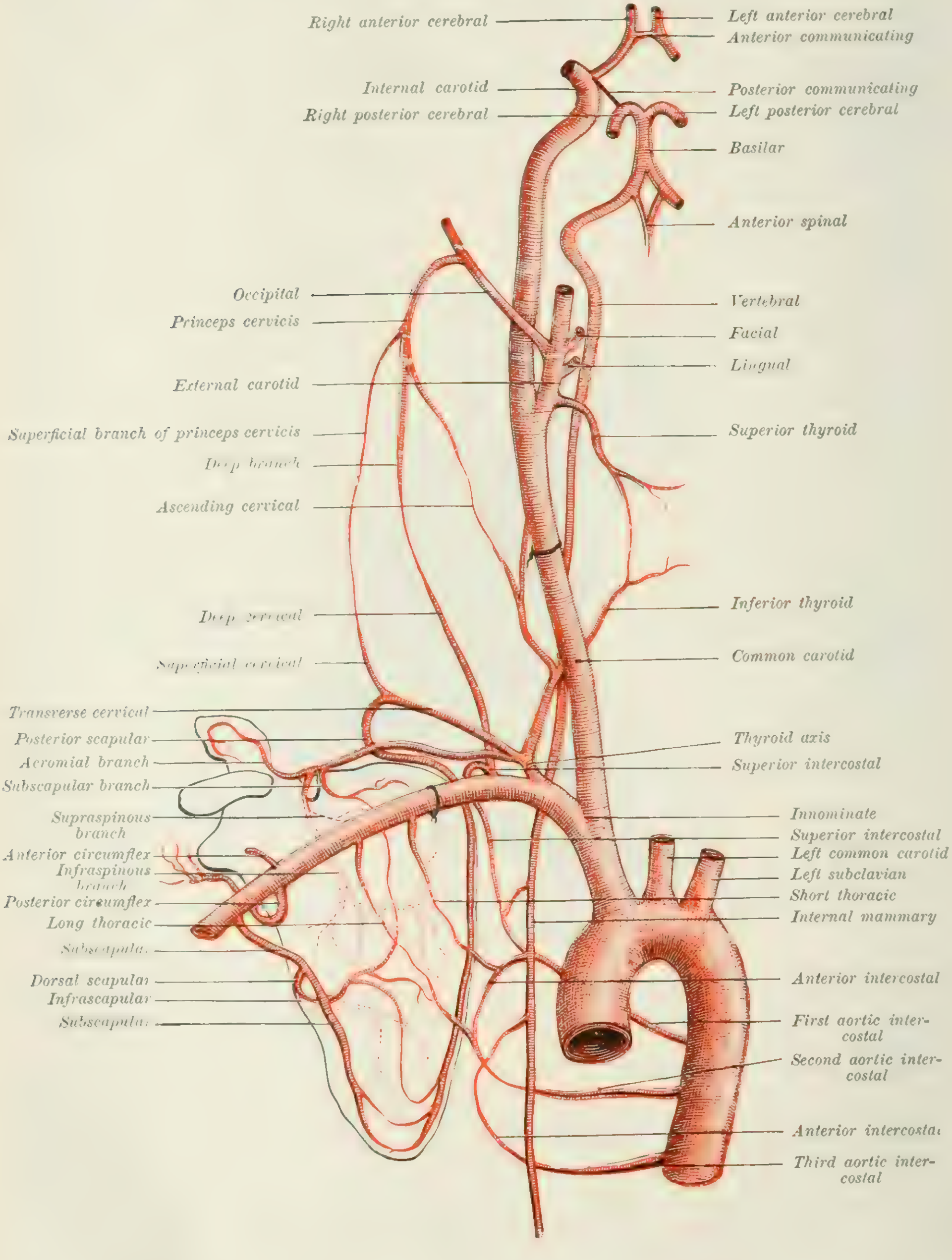

Splenius
Levator anguli scapulæ
Scalenus posticus
A SUPERFICIAL DESCENDING BRANCH OF THE CERVICAL PLEXUS
BRACHIAL PLEXUS
Transversalis colli artery (deep)
First serration of serratus magnus
PHRENIC NERVE
Scalenus anticus
First serration of serratus magnus
Subclavian vein
Suprascapular artery
Subclavian artery
Suprascapular vein
Costo-coracoid membrane and cephalic vein

The **spinal accessory** enters the anterior border of the sterno-mastoid from one to one and a half inches below the apex of the mastoid, along a line drawn downwards and outwards from the angle of the jaw. Having traversed the muscle obliquely, it pursues a similar course across the posterior triangle, disappears on a level with the sixth or seventh cervical spine beneath the trapezius, and descends under this muscle internal to the vertebral border of the scapula (Godlee). Just above the centre of the sterno-mastoid, the **small occipital, great auricular,** and **transverse cervical nerves** emerge, the first passing upwards and backwards to the scalp, the second upwards and forwards across the upper part of the sterno-mastoid to the ear, and the last turning straight forwards to the front of the neck.

The **phrenic nerve,** taking its largest root from the fourth cervical, would begin deeply about the level of the hyoid bone; thence descending under the sterno-mastoid, and passing obliquely inwards across the scalenus anticus (the posterior borders of the above two muscles roughly correspond to each other in the lower

FIG. 677.—THE COLLATERAL CIRCULATION AFTER LIGATURE OF THE COMMON CAROTID AND SUBCLAVIAN ARTERIES.

(A ligature is placed on the common carotid and on the third portion of the subclavian artery.)


Right anterior cerebral
Internal carotid
Right posterior cerebral
Occipital
Princeps cervicis
External carotid
Superficial branch of princeps cervicis
Deep branch
Ascending cervical
Deep cervical
Superficial cervical
Transrerse cervical
Posterior scapular
Acromial branch
Subscapular branch
Supraspinous branch
Anterior circumflex
Infraspinous branch
Posterior circumflex
Long thoracic
Subscapular
Dorsal scapular
Infrascapular
Subscapular
Left anterior cerebral
Anterior communicating
Posterior communicating
Left posterior cerebral
Basilar
Anterior spinal
Vertebral
Facial
Lingual
Superior thyroid
Inferior thyroid
Common carotid
Thyroid axis
Superior intercostal
Innominate
Superior intercostal
Left common carotid
Left subclavian
Short thoracic
Internal mammary
Anterior intercostal
First aortic intercostal
Second aortic intercostal
Anterior intercostal
Third aortic intercostal

part of the neck), it descends under the subclavian vein and clavicle to enter the thorax.

The level of the **brachial plexus** (upper border) would be given by a line drawn from the cricoid cartilages to the centre of the clavicle. The lowest cord (eighth cervical) is just above and behind the subclavian artery.

Collateral circulation after ligature of the common carotid (fig. 677).—This takes place by means of (1) the free communication which exists between the opposite carotids, both without and within the cranium: and (2) by enlargement of the branches of the subclavian artery on the same side as that on which the carotid has been tied. Thus, outside the cranium, the superior and inferior thyroids are the chief vessels employed (fig. 677). Within the cranium the vertebral replaces the internal carotid.

Collateral circulation after ligature of the second and third parts of the subclavian (fig. 677).—Here the following three sets of vessels are those chiefly employed:

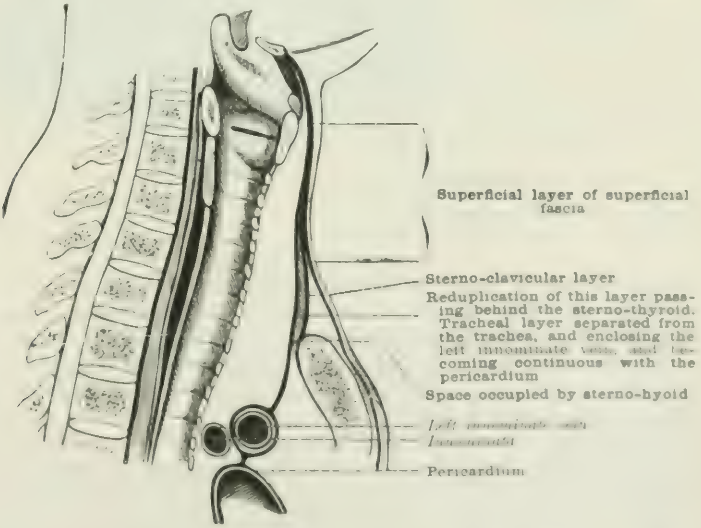
The suprascapular, the posterior scapular,	with	The acromio-thoracic, infra- and subscapular, and dorsalis scapulæ.
The superior intercostal, the aortic intercostals, and the internal mammary,	with	The long thoracic and scapular arteries.
Numerous unnamed branches passing through the axilla from branches of the subclavian,	with	Branches of the axillary.

Deep cervical fascia.—The arrangement of this must be remembered—(a) above, and (b) below, the hyoid bone. The latter is far the more important.

(a) **Arrangement above the hyoid bone.**—Here two chief layers, superficial and deep, can be made out:—(i) The **superficial**, traced upwards from the hyoid bone, encloses the submaxillary gland, passing over the mylo-hyoid, and, ascending, gives off the masseteric and parotid fasciæ, and is attached to the lower border of the zygoma. (ii) The **deeper layer,** which forms the stylo-mandibular ligament, is important in its power of checking over-action of the external pterygoid. (b) **Below the hyoid bone.**—The importance of the fascia here is infinitely greater.

FIG. 678.—DIAGRAM OF THE LAYERS OF THE DEEP CERVICAL FASCIA IN AN ANTERO-POSTERIOR SECTION OPPOSITE TO THE STERNUM. (Tillaux.)

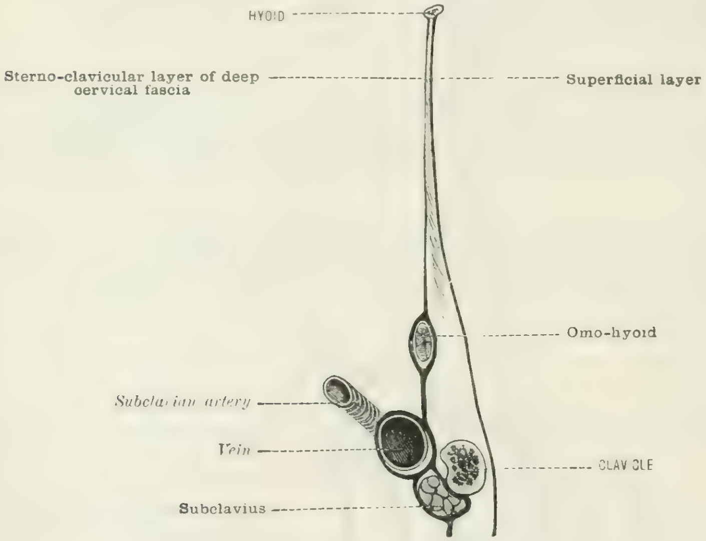
(The prevertebral layer can be seen passing down in front of the longus colli.)


Superficial layer of superficial fascia
Sterno-clavicular layer
Reduplication of this layer passing behind the sterno-thyroid. Tracheal layer separated from the trachea, and enclosing the left innominate vein, and becoming continuous with the pericardium
Space occupied by sterno-hyoid
Left innominate vein
Innominate
Pericardium

Four layers must be remembered: (i) **Superficial,** or **subcutaneous;** (ii) **sterno-clavicular;** (iii) **tracheal;** (iv) **prevertebral.** These should first be traced horizontally. (i) **Superficial,** or **subcutaneous.** This starts from the ligamentum nuchæ, encases the trapezius, forms the roof of the posterior triangle, where it is perforated by branches of the superficial cervical nerves and the external jugular vein. Passing on, it encloses the sterno-mastoid; and, passing over the anterior triangle, it meets its fellow in the middle line. Thin behind, it is thickened anteriorly, where it is united to the next layer. Behind this thickened union lie the anterior jugular veins. (ii) **Sterno-clavicular.** This is best marked below. In the middle line it meets its fellow, and blends with No. i. here also. Passing outwards, it encases the depressors of the hyoid bone, finally blending with No. i. at the posterior border of the sterno-mastoid. (iii) **Tracheal.** This lies under the depressors of the hyoid, over the trachea, also encasing the thyroid gland. Farther out, it forms the carotid sheath, and, blending with No. iv. over the anterior scalene, is thus brought into continuity with Nos. i. and ii. also. (iv) **Prevertebral.** This layer passes over the longus colli and rectus capitis anticus major.

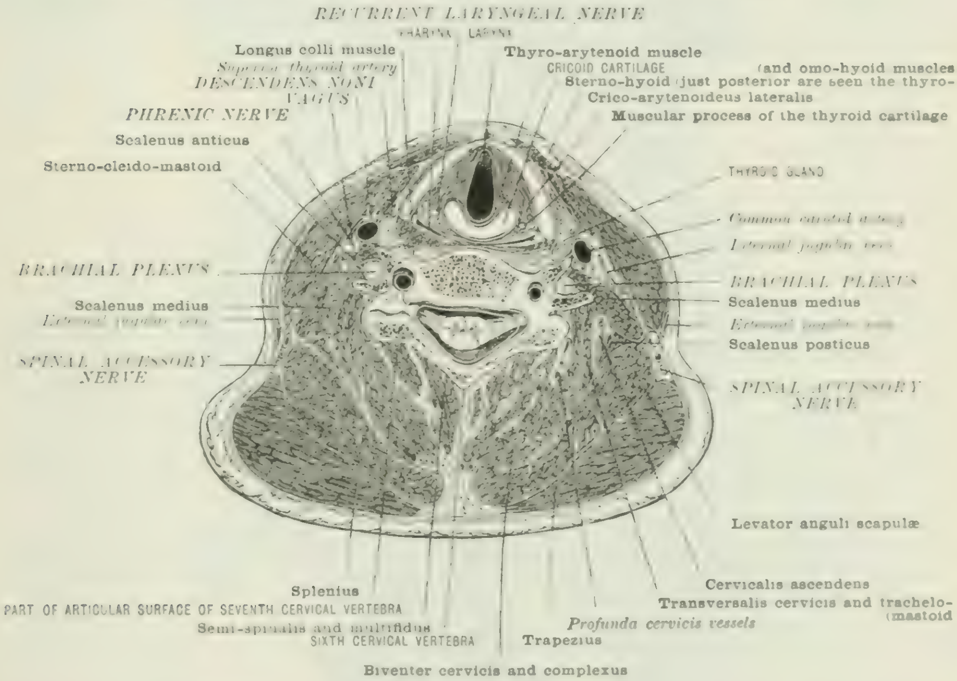
The above layers should also be traced **vertically,** with especial reference to their relations at the level of the top of the sternum and the clavicle. (*α*) **At the level of the top of the sternum.** (i) **Superficial,** passes over the sternum. (ii) **Sterno-clavicular;** this, descending in front of the depressor muscles, divides just below the thyroid cartilage into two layers, which are attached to the front and back of the sternum. Between these lie some fat and a small gland. (iii) **Tracheal;** this passes down over the trachea into the thorax (middle mediastinum). As it descends, it encases the left innominate vein, and ends by blending with the fibrous layer of the pericardium. Mr. Hilton suggested that the attachment of this fascia above, and that of the central tendon of the diaphragm below, to the pericardium served to keep this sac duly stretched, and so prevented any pressure of the lungs upon the heart. (iv) **Prevertebral;** this, descending behind the œsophagus, dips into the posterior mediastinum. (*β*) **At the level of the clavicle.** Only two of the above layers are met with so far outwards as this—(i) **Subcutaneous,** which passes over the clavicle; (ii) **sterno-clavicular,** which, having encased the omo-hyoid, passes behind the clavicle, blends with the sheath of the subclavius, and gives a sheath to the subclavian vein. That to the artery is derived from No. iii. at the scalenus anticus.

FIG. 679.—DIAGRAM OF THE ARRANGEMENT OF THE DEEP CERVICAL FASCIA, THE SECTION PASSING THROUGH THE CLAVICLE. (Tillaux.)



The following **uses and important points** with regard to the anatomy of the deep cervical fascia should be noted: (A) It **forms certain definitely enclosed spaces** in which pus or growths may form, and by the walls of which these morbid structures may be tied down and thus rendered difficult of diagnosis, while their increasing pressure may embarrass the air-passages, etc. Thus: (1) In the first space, which lies between No. 1 and the skin, the structures met with, the platysma and superficial branches of the cervical plexus, are unimportant. Any abscess here is prone to extend, but superficially. (2) In the second space, between the superficial and sterno-clavicular layers, lies a narrow space containing loose cellular tissue and lymphatic glands. Suppuration here is very common, but usually comes forwards. (3) This is the largest and most important of all. It is bounded in front by the sterno-clavicular, and behind by the prevertebral layer. Its contents are—larynx, trachea, oesophagus, thyroid, carotid sheath, glands; and below, brachial plexus, subclavian artery, and abundant loose cellular tissue for the movements of the neck. Suppuration is somewhat rarer here; but either pus or growths, if confined in this space, may have baneful effects, from pressure, or from their tendency to travel behind the sternum. (4) This space, between the prevertebral layer in front and muscles behind, is very limited. Retropharyngeal abscess forms here, and the dyspnœa it causes is thus explained. (B) The deep cervical fascia gives **sheaths** or **canals** to certain veins which perforate it, e.g. the external jugular. These are thus kept patent, and a ready passage of blood ensured from the head and neck. The carotid sheath is another and different instance. (C) It **helps to resist atmospheric pressure.** (D) Mr. Hilton's suggestion as to **its action on the pericardium** has already been mentioned.

FIG. 680.—SECTION OF NECK THROUGH THE SIXTH CERVICAL VERTEBRA. (One-half.) (Braune.)


RECURRENT LARYNGEAL NERVE
PHARYNX
LARYNX
Longus colli muscle
Superior thyroid artery
DESCENDENS NONI VAGUS
PHRENIC NERVE
Scalenus anticus
Sterno-cleido-mastoid
Thyro-arytenoid muscle
CRICOID CARTILAGE
Sterno-hyoid (just posterior are seen the thyro- (and omo-hyoid muscles
Crico-arytenoideus lateralis
Muscular process of the thyroid cartilage
THYROID GLAND
Common carotid artery
Internal jugular vein
BRACHIAL PLEXUS
Scalenus medius
External jugular vein
Scalenus posticus
SPINAL ACCESSORY NERVE
BRACHIAL PLEXUS
Scalenus medius
External jugular vein
SPINAL ACCESSORY NERVE
Levator anguli scapulæ
Splenius
PART OF ARTICULAR SURFACE OF SEVENTH CERVICAL VERTEBRA
Semi-spinalis and multifidus
SIXTH CERVICAL VERTEBRA
Cervicalis ascendens
Transversalis cervicis and trachelo-mastoid
Profunda cervicis vessels
Trapezius
Biventer cervicis and complexus

Before leaving this region, **the arrangement of the lymphatic glands of the head and neck** must be attended to. They are extremely numerous, and are chiefly arranged in the following sets: (1) **Occipital,** or **suboccipital,** along the attachment of the occipitalis. (2) The **posterior auricular,** over the insertion of the sterno-mastoid. (3) The **parotid,** just in front of the ear, partly on and partly in the substance of the parotid gland. (4) The **submaxillary**, under the cervical fascia, in the digastric triangle. This very important group receives lymph from the lower part of the face, lips, front of tongue, floor of mouth, and all the salivary glands. They drain into the superficial and deep cervical glands. (5) **Superficial cervical** glands. These lie along the external jugular, between the platysma and deep fascia. They receive lymphatics from the occipital, posterior auricular glands, the ear, and upper neck, and also some of those from the parotid and submaxillary regions. They drain partly into the deep cervical, partly into the axillary glands. (6) **Deep cervical.** These consist of two sets,—upper and lower, —lying along the carotid sheath. They receive lymph from the superficial cervical and submaxillary glands, the inside of the cranium, and pterygoid region, deep muscles of neck, palate, tonsils, larynx, pharynx, thyroid body, and upper part of trachea and œsophagus. The deep cervical glands empty into each other and below into the mediastinal and axillary lymphatics, the right lymphatic duct, and thoracic duct. Two other groups of glands—the one superficial, the other deep—must be remembered. (7) The **suprahyoid** group is a term given to a few glands situated in the middle line under the deep fascia below the chin. (8) **Retro-pharyngeal** glands. These lie between the upper part of the pharynx and the rectus capitis anticus major. They receive lymph from the naso-pharynx and drain into the deep cervical glands.

SUPERFICIAL ANATOMY OF THE THORAX

Bony points.—The top of the sternum corresponds (in inspiration) to the fibro-cartilage between the second and third thoracic vertebræ, and is distant about two and a half inches from the spine. If traced downwards, the subcutaneous sternum presents a ridge opposite to the junction of the manubrium and body, and the second costal cartilages on either side. At its lower extremity the xiphoid cartilage usually retires from the surface, presenting the depression of the scrobiculus cordis, or 'pit of the stomach.' This is opposite to the seventh costal cartilages and the expanded upper end of the recti, and corresponds to the ninth thoracic vertebra behind.

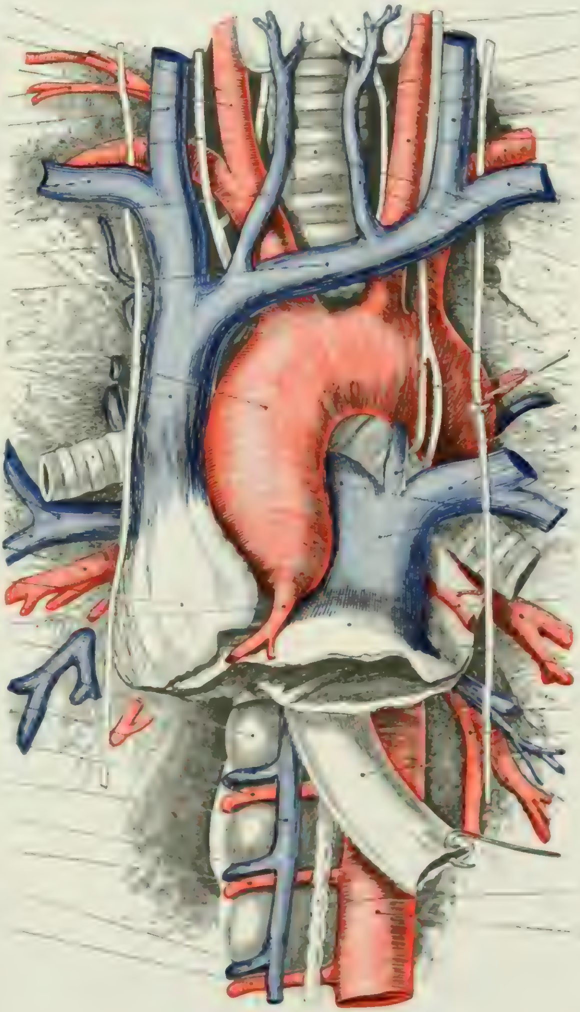
Sterno-clavicular joint.—The expanded end of the clavicle and the lack of proportion between this and the sternal facet, on which largely depends the mobility of this, the only joint that ties the upper extremity closely to the trunk, can be easily made out through the skin. Behind the joint lie, on the right side, the innominate artery, right innominate vein, and pleura; on the left, the left innominate vein, the left carotid, and the pleura.

Acromio-clavicular joint.—On tracing the clavicle outwards, it is found to rise somewhat to its articulation with the acromion. This joint has very little mobility, and owes its protection to the strong conoid and trapezoid ligaments hard by. Owing to the way in which the joint-surfaces are bevelled, that of the clavicle looks obliquely downwards, and it is an upward displacement of the clavicle which usually takes place on to the acromion.

Ribs.—In counting these, the position of the second is denoted by the transverse line at the junction of the manubrium and body of the sternum. The nipple, in the male, lies between the fourth and fifth, nearly an inch outside their cartilages. The lower border of the great pectoral corresponds to the fifth rib. The seventh, the longest of the ribs, is the last to articulate with the sternum. When the arm is raised, the first three digitations seen of the serratus magnus correspond to the fifth, sixth, and seventh ribs. The ninth rib is the most oblique. The eleventh and twelfth can be felt outside the erector spinæ. Owing to the obliquity of the ribs, their sternal ends are on a much lower level than their vertebral extremities. 'Thus the first rib in front corresponds to the fourth rib behind, the second to the sixth, the third to the seventh, the fourth to the eighth, the fifth to the ninth, the sixth to the tenth, and the seventh to the eleventh. If a horizontal line be drawn round the body from before backwards, at the level of the inferior angle of the scapula, while the arms are at the sides, the line would cut the sternum in front between the fourth and fifth ribs, the fifth rib at the nipple line, and the ninth rib at the vertebral column' (Treves). Those most frequently broken are the sixth, seventh, and eighth. The way in which the ribs are embedded in the soft parts,

FIG. 681.—THE ARCH OF THE AORTA, WITH THE PULMONARY ARTERY AND CHIEF BRANCHES OF THE AORTA.

(From a dissection in St. Bartholomew's Hospital Museum.)


RIGHT RECURRENT LARYNGEAL NERVE
Transverse cervical artery
Right common carotid artery
Suprascapular artery
Internal jugular vein
PNEUMOGASTRIC NERVE
Subclavian vein
Inferior thyroid vein
PHRENIC NERVE
Left innominate vein
Ascending aorta
Superior vena cava
RIGHT BRONCHUS
Branch to superior lobe of lung
Upper branch of right pulmonary artery
Branch to middle lobe of lung
Right pulmonary vein
RIGHT AURICLE
Right coronary artery
Lower branch of right pulmonary artery
THORACIC VERTEBRA
Intercostal vein
Intercostal artery
Vena azygos major
Intercostal vein
Intercostal artery
Intercostal vein
Intercostal artery
THYROID BODY
LEFT RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
Left internal jugular vein
Left common carotid artery
Left subclavian artery
Left subclavian vein
TRACHEA
Inferior thyroid vein
PHRENIC NERVE (hooked aside)
RECURRENT LARYNGEAL NERVE
PNEUMOGASTRIC NERVE
DUCTUS ARTERIOSUS
Left pulmonary artery
Pulmonary artery
Right pulmonary artery
LEFT BRONCHUS
Left coronary artery
Upper left pulmonary vein
RIGHT VENTRICLE
Lower left pulmonary artery
Lower left pulmonary vein
ŒSOPHAGUS
THORACIC DUCT

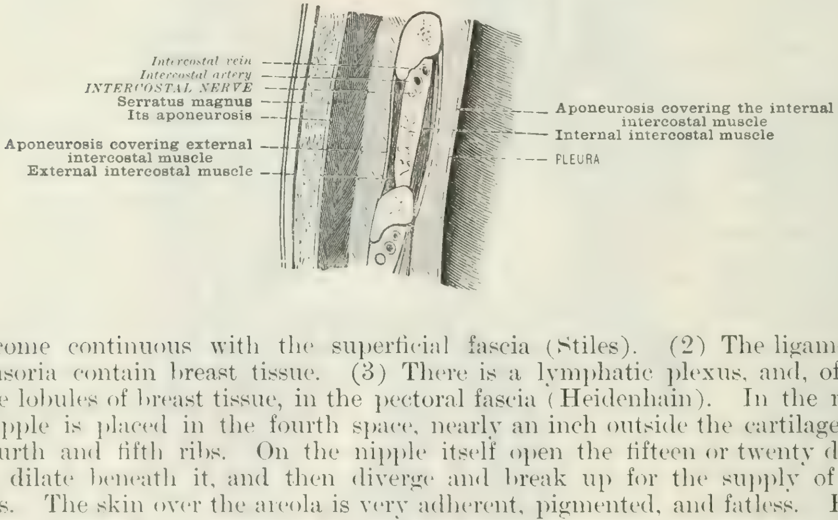
and the fact that the fragments are often held in place by the periosteum, accounts for the difficulty which is often met with in detecting crepitus. The intercostal spaces are wider in front than behind. The three upper are the widest of all.

Structures passing through the upper aperture of the thorax.—If a horizontal section is made passing through the manubrium sterni, upper border of the first rib, and upper part of the first thoracic vertebra, the following structures are met with:—(1) **In the middle line.** Sterno-hyoid and sterno-thyroid muscles, with their sheaths of deep cervical fascia, cellular tissue in which are the remains of the thymus gland, the inferior thyroid veins, the trachea and tracheal fascia, the œsophagus and longus colli muscles. Between the trachea and œsophagus are the recurrent laryngeal nerves. (2) **On each side.** The apex of the lung, covered by pleura, rises about an inch and a half above the first rib. Between it and the trachea and œsophagus lie the following: the internal mammary artery, the phrenic nerve; on the right side, the innominate vein and artery, with the vagus between the two, the cardiac nerves, and the right lymphatic duct. On the left side are the common carotid and subclavian arteries, with the left vagus between them, the cardiac nerves, and the thoracic duct. Farthest back and on each side are the trunk of the sympathetic, the superior intercostal artery, and the first thoracic nerve.

Structures found in an intercostal space.—(1) Skin; (2) superficial fascia, with cutaneous vessels and nerves; (3) deep fascia; (4) external intercostal; (5) cellular interval between intercostals, containing trunks of intercostal vessels and nerves; (6) internal intercostals; (7) thin layer of fascia; (8) subpleural connective tissue; (9) pleura (fig. 682).

The mamma.—This lies partly over the sheath of the pectoralis major and partly over the serratus magnus. It is usually described as reaching from the third to the fifth or sixth rib, and from the sternum to the anterior border of the axilla. It is most important to remember that the breast is often a much more extensive structure than would be included in the above very limited description. Thus (1) the breast is not encapsuled at its periphery, its tissue branching and breaking up here to become continuous with the superficial fascia (Stiles). (2) The ligamenta suspensoria contain breast tissue. (3) There is a lymphatic plexus, and, often, minute lobules of breast tissue, in the pectoral fascia (Heidenhain). In the male the nipple is placed in the fourth space, nearly an inch outside the cartilages of the fourth and fifth ribs. On the nipple itself open the fifteen or twenty ducts which dilate beneath it, and then diverge and break up for the supply of the lobules. The skin over the areola is very adherent, pigmented, and fatless. Here also are groups of little swellings corresponding to some twenty large sebaceous follicles. The skin over the breast is freely movable, and united to the fascia which encases the organ, and thus to the interlobular connective tissue, by bands of the same structure—the ligamenta suspensoria. Under the breast, and giving it its mobility, is a cellulo-fatty layer, the seat of submammary abscess. The **nerves** which supply the breast are the anterior cutaneous branches of the second, third, fourth, and fifth intercostal nerves, and the lateral branches of the last three. The connection of these trunks serves to explain the diffusion of the pain often observed in painful affections of the breast. Thus pain may be referred to the side of the chest and back (along the above intercostal trunks), over the scapula, along the inner side of the arm (along the intercosto-humeral nerve, a branch of the second intercostal), or up into the neck, probably along the supra-clavicular branch from the cervical plexus, which communicates with the second intercostal (Treves). The gland is supplied by the following **arteries**: the aortic intercostals of the second, third, fourth, and fifth spaces, similar intercostal branches from the

FIG. 682.—SECTION OF THE SIXTH LEFT INTERCOSTAL SPACE, AT THE JUNCTION OF THE ANTERIOR AND POSTERIOR THIRDS. (Tillaux.)

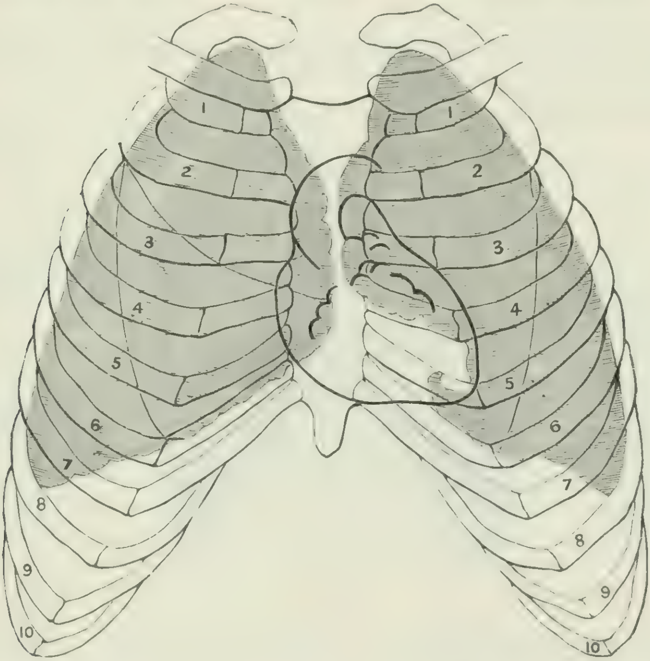

Intercostal vein
Intercostal artery
INTERCOSTAL NERVE
Serratus magnus
Its aponeurosis
Aponeurosis covering external intercostal muscle
External intercostal muscle
Aponeurosis covering the internal intercostal muscle
Internal intercostal muscle
PLEURA

internal mammary, which run outwards, two small branches to each space, perforating branches from the same vessel, one or two given off opposite to each space, the long thoracic and external mammary (when present) from the axillary.

The lymphatics may be divided into **two sets**—(A) The majority which go along the chief vessels to the glands in the axilla, where the following groups are to be found: (1) Axillary; (2) subscapular; (3) pectoral, along the long thoracic; (4) subclavian, or infra-, and supraclavicular. All these anastomose with each other, and also with (B) a much smaller set of lymphatics, which pass from the inner part of the breast, through the anterior ends of the intercostal space, to the internal mammary or anterior intercostal lymphatic glands. Thus they reach the mediastinal and deeper lymphatics.

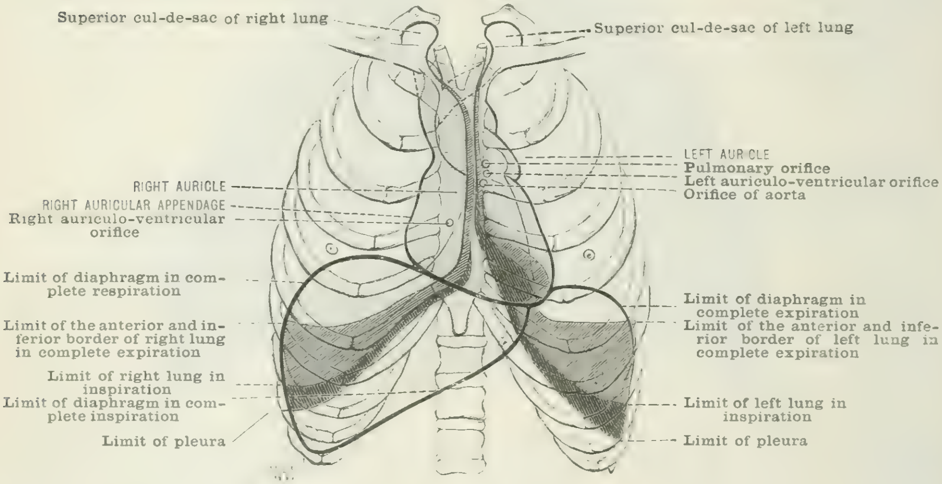
Parts behind manubrium.—There is little or no lung behind the first bone of the sternum, the space being occupied by the trachea and large vessels, as follows: —The left innominate vein crosses behind the sternum just below its upper border. Next come the great primary branches of the aortic arch. Deeper still is the trachea, dividing into its two bronchi opposite to the junction of the first and second bones of the sternum. Deepest of all is the œsophagus. About one inch from the upper border of the sternum is the highest part of the aortic arch, lying on the bifurcation of the trachea (Holden).

FIG. 683.—OUTLINE OF THE HEART, ITS VALVES, AND THE LUNGS (SHADED). (Holden.)



Outline of the lungs. Their relation to the chest-wall.—The apex of the lung rises about an inch and a half (from half an inch to an inch and three-quarters) above the first rib into the base of the posterior triangle lying behind the inner end of the clavicle, the sterno-mastoid, and the anterior scalene, covered by the pleura and deep cervical fascia, and having the subclavian artery arching over it. From the apices the thin anterior borders converge inwards behind the sterno-clavicular joints, and the first piece of the sternum to the junction of this with the second, almost meeting at this point. Thence the two borders descend parallel and close to each other (the right sometimes passing just beyond the middle line), and thus covering over the heart and large vessels, to a point midway between the fourth pair of costal cartilages, where they diverge, but not to an equal degree. The right descends in an almost straight line as far as the sixth chondro-sternal joint. The left is deeply notched (incisura cardiaca). The lower borders of the lung pass downwards and outwards across the sides of the chest from the sixth chondro-sternal joint to the tenth thoracic spine. In the nipple-line the lung reaches the sixth rib, in the posterior fold of the axilla, the eighth, and opposite the angle of the scapula (the arms being close to the sides), the tenth rib. Thus, to map out the lung, a line should be drawn from the apex, a point about an inch and a half above the first rib, a little outside the sterno-mastoid muscle, obliquely inwards, behind the sterno-clavicular joint, to near the centre of the junction of the first and second bones of the sternum. Thence, on each side, a line should be drawn slightly convex as far as a similar point on the sternum lying opposite the articulation of the fourth chondro-sternal joint. On the right side the line may be dropped as low as the sixth chondro-sternal joint; on the left (to show the incisura cardiaca) a line should be drawn sloping outwards from the fourth chondro-sternal articulation along the lower border of the fourth rib, across the fourth interspace, to a point about an inch and a half below the left nipple (male) and an inch to its inner side. This point, lying in the fifth space, marks the apex of the heart. The lower border of the lung will be marked on the right side by a line drawn from the sixth chondro-sternal articulation across the side of the chest down to the tenth thoracic spine. The lower border of the left lung will follow a similar line, starting on a level with a similar joint (sixth chondro-sternal joint), but much farther out than on the right side, i.e. in the fifth space, about three inches to the left of the middle line, or a point corresponding to the heart's apex. This margin of the lung descends about an inch and a half in deep inspiration, according to Godlee. The position of the great fissure in each lung may be ascertained approximately by drawing a line from the second thoracic spine to the sixth rib in the nipple line; and the smaller fissure of the right lung extends from the middle of the foregoing to the junction of the fourth costal cartilage with the sternum. It will be seen from the above that there is little lung behind the manubrium. The connective tissue here between the lung margins contains up to puberty the thymus, and, later, its remains. The **pleura** reaches lower down than the lung. Thus its lower margin reaches along the seventh rib cartilage near the sternum; in the axillary line it has reached the lower margin of the ninth rib; farther back it reaches as low as the twelfth rib, or the eleventh thoracic spine. Thus it may be opened in operations in the loin, e.g. on the kidney, or in removing the twelfth rib. Mr. Holden thus draws attention to this lower level of the pleura: 'Since the pleura lines the inside of the last rib, a musket-ball or

Fig. 684.—Diagram of the Relations of the Thoracic Viscera to the Walls of the Chest. (Bellamy.)


Superior cul-de-sac of right lung
Superior cul-de-sac of left lung
LEFT AURICLE
Pulmonary orifice
Left auriculo-ventricular orifice
Orifice of aorta
RIGHT AURICLE
RIGHT AURICULAR APPENDAGE
Right auriculo-ventricular orifice
Limit of diaphragm in complete respiration
Limit of diaphragm in complete expiration
Limit of the anterior and inferior border of right lung in complete expiration
Limit of the anterior and inferior border of left lung in complete expiration
Limit of right lung in inspiration
Limit of diaphragm in complete inspiration
Limit of left lung in inspiration
Limit of pleura
Limit of pleura

other foreign body, loose in the pleural sac and rolling on the diaphragm, might fall to the lowest part of the sac, which would be between the eleventh and twelfth ribs. The ball might be extracted here. The chest might also be tapped here, but not with a trocar, since a trocar would penetrate both layers of pleura and go through the diaphragm into the abdomen. The operation should be done cautiously by an incision beginning about two inches from the spine, on the outer border of the erector spinæ, on a level between the spines of the eleventh and twelfth thoracic vertebræ. The intercostal artery will not be injured if the opening be made below the middle of the space, which is very wide.'

Outline of the heart. Its relation to the chest-wall.—The upper limit of the heart (base) will be defined by a line crossing the sternum a little above the upper border of the third costal cartilage, reaching about half an inch to the right and about one inch to the left. Its apex corresponds to a point in the fifth space, about two inches below the male left nipple, and an inch to the inner side. This point will be about three inches from the left border of the sternum. The right border (right auricle) will be given by a line, slightly convex outwards, drawn from the right extremity of the upper border to the right seventh chondro-sternal joint. If another line, similarly slightly convex, be drawn onwards from this point across the last piece of the sternum, just above the xiphoid cartilage, to the apex, it will give the lower border (right ventricle), which rests on the central tendon of the diaphragm. The left border (left ventricle) will be given by a line, convex to the left, passing from the left extremity of the upper border to the apex, well inside the nipple line. This line should be three inches from the middle of the sternum at the level of the fourth costal cartilage.

If a circle two inches in diameter be described around a point midway between the left nipple and the lower end of the gladiolus, it will define with sufficient accuracy for practical purposes that part of the heart which lies immediately behind the chest wall, and which is uncovered by lung or pleura (Latham).

The valves.—The **pulmonary valves** (the most superficial) lie, in front of the aortic, behind the left chondro-sternal joint, and opposite to the upper border of the third costal cartilage. The **aortic valves** lie behind and a little below these, opposite to the inner end of the third intercostal space, and on a level with the lower border of the third costal cartilage. The **auriculo-ventricular openings** lie at a somewhat lower level than that of the aortic and pulmonary. Thus the **tricuspid valves** lie behind the sternum at the level of the fourth intercostal space; and the **mitral valves**, the most deeply placed of all, lie a little to the left of these, behind the left edge of the sternum and the fourth left costal cartilage.

'Thus these valves are so situated that the mouth of an ordinary-sized stethoscope will cover a portion of them all, if placed over the juncture of the third intercostal space, on the left side, with the sternum. All are covered by a thin layer of lung; therefore we hear their action better when the breathing is for a moment suspended' (Holden).

Relation of vessels to the wall of the thorax.—**Aortic arch.**—The ascending part reaches from a spot behind the sternum, a little to the left of the centre, on a level with the third left costal cartilage, to the upper border of the second right cartilage; thus it passes upwards, backwards, and to the right, and is about two inches long. The transverse part then crosses to the left behind the sternum (the highest part of the arch being about an inch below the notch), reaching from the second right costal cartilage to the lower border of the fourth thoracic vertebra on the left side. This part recedes from the surface, and, with the next, cannot be marked out on the surface. The third, or descending part, the shortest of the three, reaches from the lower border of the fourth to that of the fifth thoracic vertebra.

Innominate artery.—A line drawn from the top of the arch, about an inch below the sternal notch, and a little to the right of the centre, to the right sterno-clavicular joint, will give the line of this vessel.

Left common carotid.—This vessel will be denoted by a line somewhat similar to the above, passing from the level of the arch a little to the left of the last starting point to the left sterno-clavicular joint.

Left subclavian artery.—A line from the end of the transverse arch, behind the left of the sternum, straight upwards to the clavicle, delineates the vertical thoracic course of the long left subclavian artery (Sheild).

Innominate veins.—The **left,** three inches long, extends very obliquely from the left sterno-clavicular joint, to a point half an inch to the right of the sternum, in the first intercostal space. The **right,** about an inch long, descends almost vertically to the above point from the right sterno-clavicular joint.

Venæ cavæ.—The **superior** descends from the point above given for the meeting of the innominate veins in the first intercostal space, close to the sternum, and perforates the right auricle on a level with the third costal cartilage. The **inferior vena cava.**—The opening of this vein into the right auricle lies under the middle of the fifth right interspace and the adjacent part of the sternum.

Internal mammary artery.—This descends behind the clavicle, the costal cartilages, and the first six spaces, about half an inch from the edge of the sternum. In the sixth intercostal space it divides into musculo-phrenic and superior epigastric arteries.

THE ABDOMEN

Skin markings; bones and muscular landmarks.—The **linea alba,** or meeting of the aponeuroses of the great abdominal muscles over, under, and between the recti, reaches from the apex of the xiphoid cartilage to the symphysis. It is best marked above the umbilicus. Its little vascularity and comparative thinness fit this line for the point of election for many of the operations on the abdominal cavity. In the linea alba, a little below its centre, is the umbilicus. This corresponds to the level of the fibro-cartilage between the third and fourth lumbar vertebrae, the tip of the third lumbar spine (Windle), the highest point of the iliac crests, and a point three-quarters of an inch to one inch above the bifurcation of the aorta.

On each side of the linea alba, and about two and a half to three inches from it (according to the muscular development), a line, curved with a slight convexity outwards, the **linea semilunaris,** denotes the point of division of the abdominal aponeuroses, reaching from the ninth costal cartilage to the pubic spine. Between the linea alba and the linea semilunaris run the three lineæ transversæ, of which one is placed at the umbilicus, another at the xiphoid cartilage, and a third between the two, on a level with the tenth costal cartilage. There is, rarely, a fourth below the umbilicus.

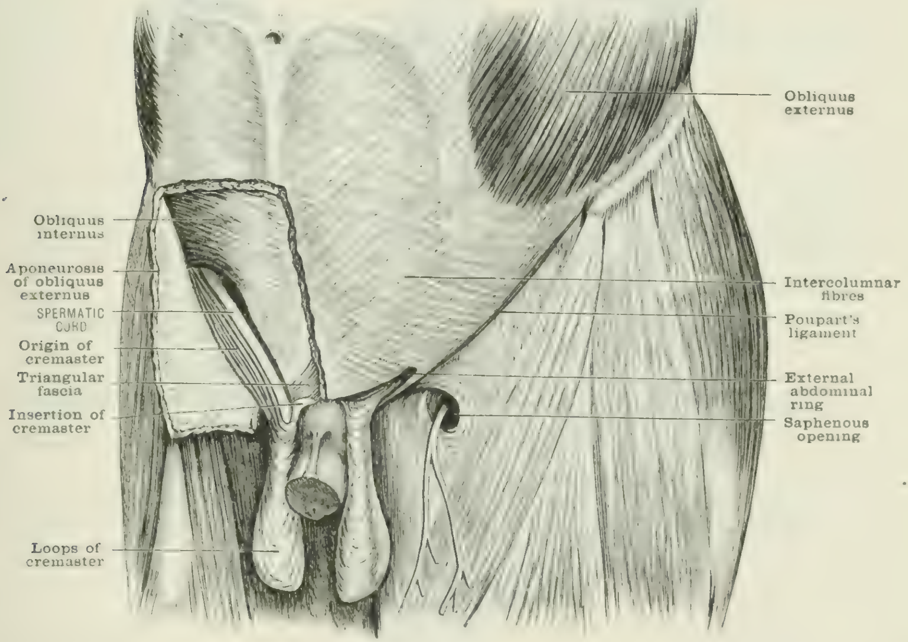
In very corpulent subjects two deep transverse furrows run across the abdomen. One runs across the navel and completely conceals it; the other is lower down, just above the fat of the pubes. In tapping the bladder above the pubes in such a case, the trocar should be introduced where this line intersects the linea alba (Holden).

A transverse line drawn from one anterior superior spine to the other crosses at about the level of the top of the promontory of the sacrum. Such a line will always show whether the pelvis is horizontal or not (Holden).

Poupart's ligament corresponds to a line drawn with a slight curve downwards between the anterior superior spine and the pubic spine. The first of these bony prominences corresponds to the starting-point of the above ligament, the attachment of the fascia lata to the ilium, the meeting of the fleshy and aponeurotic parts of the external oblique (denoted by a line drawn upwards from this spine to the ninth costal cartilage, or often a little anteriorly to these points), the point of emergence of the external cutaneous nerve, and part of the origins of the internal oblique, transversalis, and tensor vaginæ femoris. The pubic spine marks the outer pillar of the **external abdominal ring,** the mouth of which corresponds to the crest, or that part of the pubes lying between the spine and the symphysis.

The ring, and especially its outer pillar, can easily be felt by invaginating the scrotal skin with a finger, and pushing upwards and outwards. In a female patient, if the thigh be abducted, the tense tendon of the adductor longus will lead up to the site of the ring. The **internal ring** is situated about half an inch above the centre of Poupart's ligament; oval in shape, and nearly vertical in direction, it has the arching fibres of the transversalis above it, and to its inner side the deep epigastric artery. The **canal** runs obliquely downwards and forwards between the two rings. In the adult it is about an inch and a half long, but in early life, and in adults with a large hernia dragging upon the parts, the two rings are much nearer, and may be one behind the other. If the external ring be exposed, and the finger thrust carefully up the canal, the following structures will be noted:—After the finger has carefully dilated the canal, its tip will be prevented from entering the abdomen by the infundibuliform fascia. If it be pressed downwards, it will feel Poupart's ligament, which, with the meeting of the fascia transversalis, forms the floor; above, it will be arrested by the arching fibres of the internal oblique and transversalis, coming down to the pectineal line to form the conjoined tendon. Towards the abdominal wall the finger will feel the aponeurosis of the external oblique stretching over the whole anterior aspect of the canal; if turned towards the belly cavity, the finger would feel less resistant layers, viz. extra-peritoneal fat and peritoneum, and, behind the external ring, the conjoined tendon. The finger would, of course, also take notice of the spermatic cord in the male and the round ligament in the female, and investigate any alteration in the former, and isolate the vas deferens.

FIG. 685.—OBLIQUUS EXTERNUS AND FASCIA LATA.

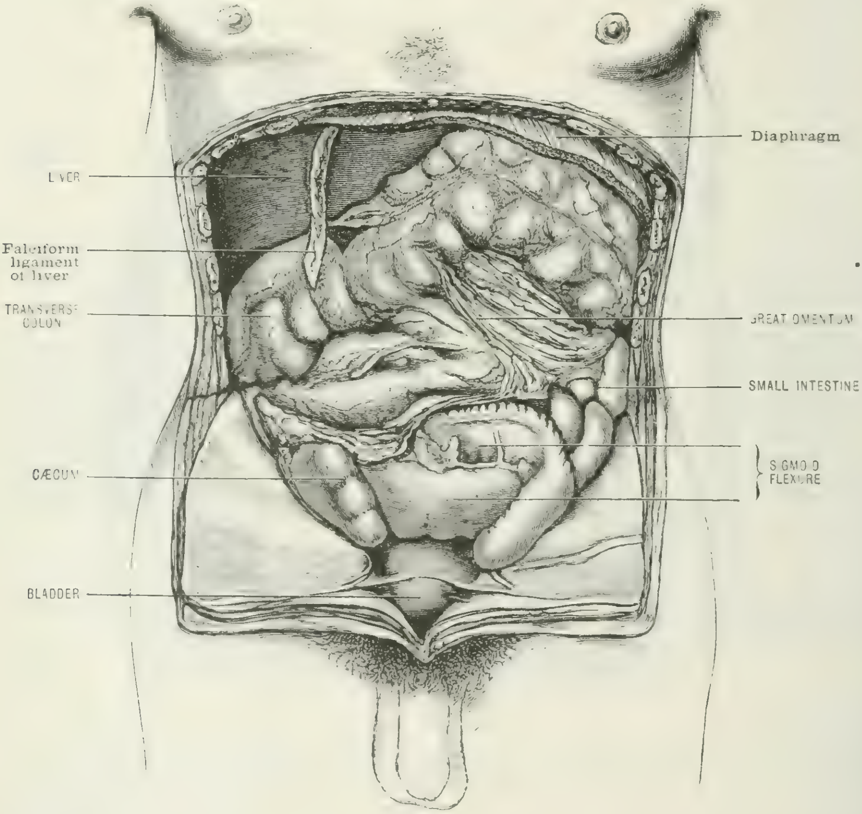


Vessels in the abdominal wall.—The three superficial branches of the common femoral, the external pudic (superior and inferior), epigastric and circumflex iliac, supply the lower part of the abdominal wall and the adjacent groin and genitals. The only others that have to be remembered are the deep epigastrics and epigastric branch of the internal mammary, the deep circumflex iliacs, the last two intercostals, and the abdominal branches of the lumbar arteries. Of these, the deep epigastric is the most important; its course will be marked out by a line drawn from a point just internal to the centre of Poupart's ligament, upwards and inwards to the inner side of the internal ring, and thence to a point about midway between the pubes and umbilicus. Here the vessel, which at first lies between the peritoneum and fascia transversalis, perforates the latter and, passing over the fold of Douglas, enters the sheath of the rectus. It then runs upwards, closely applied to the back of that muscle, and, a little above the level of the umbilicus, divides into branches which anastomose with the epigastric or abdominal branch of the internal mammary.

Lymphatics.—It is sufficiently correct to say here that those above the umbilical line go to the axillary, and those below that line to the femoral glands.

Nerves.—The lower seven intercostals and the ilio-hypogastric and ilio-inguinal supply the abdominal wall. The sixth and seventh intercostals supply the skin over 'the pit of the stomach'; the eighth the area of the middle linea transversa; the tenth that of the umbilicus; the last thoracic, ilio-inguinal, and ilio-hypogastric, the region above Poupart's ligament, and that of the pubes. The ilio-hypogastric supplies the skin over the external ring; the ilio-inguinal that over the cord and scrotum. The last thoracic and ilio-hypogastric cross the iliac crest to supply the skin of the buttock.

FIG. 686.—THE VISCERA AS SEEN ON FULLY OPENING THE ABDOMEN WITHOUT DISARRANGEMENT OF THE INTERNAL PARTS. (After Sarazin.)



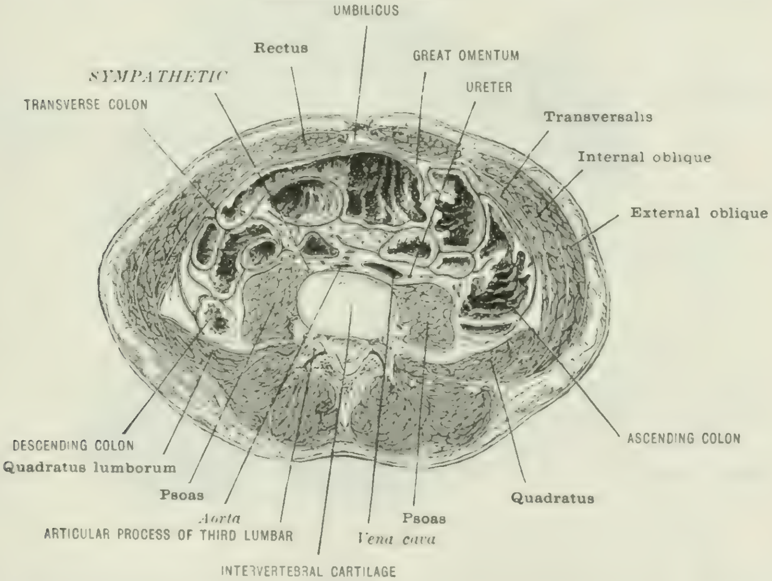
Viscera and visceral regions.—The general form of the abdominal space, and the relations of the several organs before they are disturbed from their normal positions, are given on pages 959 and 960. The arbitrary regions into which the abdomen is usually divided are described at the end of this article.

The diaphragm.—The upper limit of the abdomen rises to the following levels: Its central tendon to about the lower end of the sternum, or the seventh chondro-sternal joint: the right half to about the level of the fifth rib, or about one inch below the nipple; the left half not rising quite so high.

Viscera behind the linea alba.—From above downwards there are the following (fig. 686):—(1) **Above the umbilicus**—the left lobe of the liver, the stomach, the transverse colon, part of the great omentum, the pancreas and solar plexus. (2) **Below the umbilicus**—the rest of the great omentum, covering in the small intestines and their mesentery. In the child, the bladder occupies a partly abdominal position; and in the adult, the same viscus, if distended, may rise out of the pelvis and displace the above structures, raising the peritoneum until, if distended half way to the umbilicus, there is an area of nearly two inches safe for operations above the symphysis. The gravid uterus also rises along the linea alba.

The liver (figs. 579, 580, and 581).—In the erect position, the anterior thin edge of the liver projects about half an inch below the costal cartilages, but can only be made out with difficulty in this position. It may also be displaced downwards by pleuritic effusion or tight lacing. The liver is also, proportionately, much larger in little children.

FIG. 687.—SECTION OF ABDOMEN BETWEEN THE THIRD AND FOURTH LUMBAR VERTEBRÆ. (Braune.)

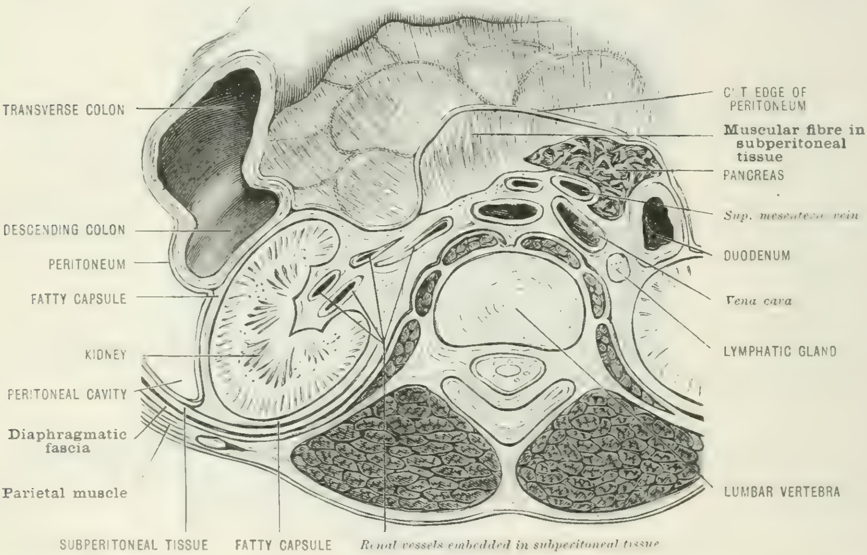

UMBILICUS
Rectus
GREAT OMENTUM
SYMPATHETIC
URETER
TRANSVERSE COLON
Transversalis
Internal oblique
External oblique
ASCENDING COLON
DESCENDING COLON
Quadratus lumborum
Psoas
Quadratus
Aorta
Psoas
ARTICULAR PROCESS OF THIRD LUMBAR
Vena cava
INTERVERTEBRAL CARTILAGE

Of the three parts of the liver (according to the regions which it occupies), that in the right hypochondrium corresponds to the lower margin of the thorax; but in the epigastric region the anterior margin, running obliquely across from the ninth right to the eighth left costal cartilage, crosses the middle line about a hand's breadth below the sterno-xiphoid articulation (Godlee). The size of the left lobe varies. In infants it will occupy the left hypochondrium; in adults its extent to the left will vary from a point an inch and a half or two inches beyond the sternum to the left nipple line. The level of the upper border varies also with position, respiration, etc. It may be represented, on the right, by a line drawn about one inch below the nipple, along the seventh rib, towards the middle line, the fifth chondro-sternal joint, and the sterno-xiphoid articulation (or central tendon of the diaphragm); on the left side it does not reach quite so high: thus its level would be marked by the sixth chondro-sternal joint. Behind, the liver would be below the base of the right lung, on a level with the tenth thoracic spine (figs. 708, 709, and 710).

Gall-bladder.—The fundus of this, situated in a fossa on the under surface of the right lobe of the liver, and having the quadrate lobe to its left, lies opposite to the right ninth costal cartilage, close to the outer edge of the rectus. It is in contact with the hepatic flexure of the colon and the first piece of the duodenum.

Stomach (figs. 566–569, p. 960).—This organ varies in position more than any other, owing to its mobility, save at the cardiac orifice, and to its varying distension. When empty and contracted, it lies far back in the abdomen, under the left lobe of the liver, and in front of the pancreas. When much distended, its pyloric end moves to the right, and the organ comes forwards, pushing against the liver and abdominal wall; and upwards, against the diaphragm, and thus against the heart and left lung. If moderately distended, the cardia will be found under the seventh left chondro-sternal joint, about one inch beyond the sternum. The pylorus is very mobile, but a spot near the end of the cartilage of the eighth rib will denote it with sufficient accuracy. It is on a deeper plane than the cardia. By joining these two points with lines representing the lesser and greater curvatures, the stomach can be marked out (figs. 708, 709). The usual inaccuracies committed in delineating the stomach are as follows: The viscus is marked too horizontally—students forget its oblique position. The greater curvature and fundus are not marked high enough on the left side. They are placed high up under the left arch of the diaphragm, well to the left of the middle line, as high as the sixth chondro-sternal joint. The lesser curvature is usually made too curved and too horizontal (Sheild).

FIG. 688.—DIAGRAM SHOWING RELATION OF KIDNEY TO CAPSULE.


TRANSVERSE COLON
DESCENDING COLON
PERITONEUM
FATTY CAPSULE
KIDNEY
PERITONEAL CAVITY
Diaphragmatic fascia
Parietal muscle
SUBPERITONEAL TISSUE
FATTY CAPSULE
Renal vessels embedded in subperitoneal tissue
CUT EDGE OF PERITONEUM
Muscular fibre in subperitoneal tissue
PANCREAS
Sup. mesenteric vein
DUODENUM
Vena cava
LYMPHATIC GLAND
LUMBAR VERTEBRA

The pancreas.—This lies a little obliquely behind the stomach, crossing the aorta, inferior cava, and spine about the junction of the first and second lumbar vertebræ, or three inches above the umbilicus (fig. 587, p. 987, and fig. 710, p. 1147). A little lower is the third piece of the duodenum, reaching to within an inch of the umbilicus (Godlee).

Intestines—(A) **Small.**—The only parts of these that can be localised at all definitely are the duodenum and its junction with the jejunum and the ending of the ileum in the cæcum. The first piece of the **duodenum** lies in the right hypochondrium, usually near the gall-bladder (*vide supra*), reaching from the pylorus upwards, backwards, and to the right. This is the most mobile of the three parts. The second, or descending, is in relation with the head of the pancreas, and reaches the right lumbar region, descending as low as the second or third lumbar vertebra. The third, or oblique, portion passes from the third lumbar vertebra obliquely from right to left across the second, and, ascending, ends in the jejunum on the left side of the spine. This portion of the intestine being firmly secured in place by fibres from the left crus of the diaphragm and the commencement of the mesentery, accounts for rupture of the intestine usually occurring near this spot.

Of the **jejunum** and **ileum** it may be said that, if undistended, the coils of the jejunum (about eight feet) occupy rather the left side, and that of the ileum (twelve feet), the right side, in addition to the central regions, where the jejunum would be chiefly above, and the ileum below. According to Mr. Treves, the coils most usually found in the pelvis belong to the terminal part of the ileum, and that part of the intestine which has the longest mesentery, viz.: that extending between two points respectively six and eleven feet from the end of the duodenum. But as there is no definite limit between the jejunum and ileum, so is there no regular arrangement of their coils. If present, a Meckel's diverticulum would arise from one to three feet from the termination of the ileum.

The upper limit of the **mesentery** would be marked by a spot about three inches above the umbilicus and a little to the left of the centre of the body of the second lumbar vertebra. From this point it extends obliquely to the right iliac fossa, where it ends in the ileo-cæcal junction, about four inches above the centre of Poupart's ligament. Its average length is about eight inches.

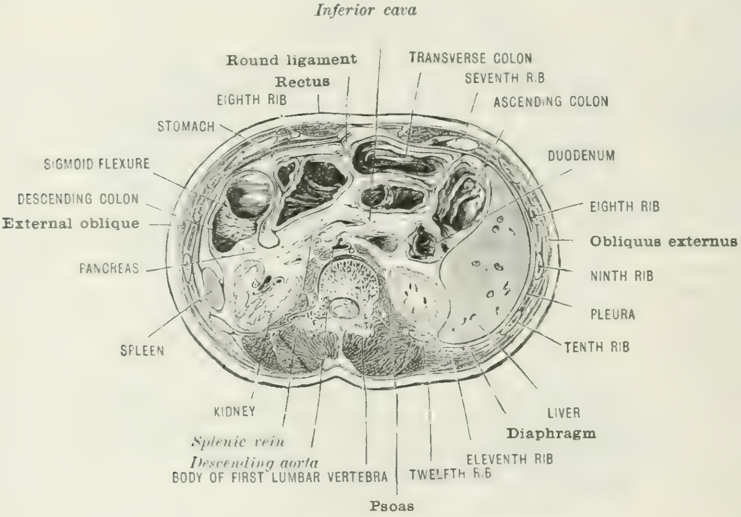
(B) **Large intestine.**—The **cæcum** measuring about two and a half inches both in its vertical and transverse diameters, lies in front of the ilio-psoas, and should be so mapped out behind the anterior abdominal wall as to lie above the outer half of Poupart's ligament, and with its apex or lowest point projecting just beyond the inner border of the psoas, and thus corresponding to a point a little to the inner side of the centre of Poupart's ligament. Not unfrequently it lies more external, still in the right iliac region, but entirely on the iliacus. The **ileo-cæcal valve,** or junction of the small and large intestines, corresponds to a point about two inches internal to and a little above the anterior superior spine. The base of the **vermiform appendix,** which usually comes off close to the valve on the posterior wall of the cæcum, would be represented by the above point with sufficient accuracy. The appendix itself, averaging four inches in length, of the size of a goose-quill, and usually twisted on itself owing to the shortness of its mesentery, generally projects behind the cæcum, ileum, and mesentery, in the direction of the spleen (Treves), or downwards to the left, so as to approach the brim of the pelvis. The **ascending colon,** covered by small intestine, lies deeply as it passes up over the kidney through the right lumbar region. The hepatic and splenic flexures lie deeply also in the hypochondriac regions, the splenic being higher than the hepatic, and behind the stomach, while the former is in contact with the under surface of the liver. Between the two courses the **transverse colon,** in close contact with the great curvature of the stomach, and varying in position from one, two, or three inches above the umbilicus, to one nearer or even below this point. The **descending colon** follows a similar course to the ascending; and the sigmoid flexure occupies the left iliac fossa, and from this point passes over the brim of the pelvis. Except at its hepatic and splenic flexures, the colon can be examined through the parietes, aided by an anæsthetic. The cæcum is the most superficial of all.

Landmarks for lumbar colotomy.—(1) The lower border and tip of the last rib, which varies in length; (2) a point half an inch behind the centre of the iliac crest, this point being found by accurate measurement along the crest between the anterior and posterior spines (Allingham); (3) a line drawn vertically upwards from the last-mentioned point to the last rib. This gives with sufficient correctness the line of the outer edge of the quadratus, and the position of a normal colon.

Iliac or anterior colotomy.—The incision here, whether for opening the sigmoid flexure or the cæcum, is one, two and a half, or three inches long, made parallel with the outer part of Poupart's ligament, and one and a half inches above it.

The kidneys.—These lie at the back of the abdominal cavity so deeply in the hypochondriac and epigastric region as to be beyond palpation, unless enlarged or unduly mobile. The lower end of the right being slightly lower than its fellow, encroaches in health upon the lumbar and epigastric region. These organs lie much higher than is usually supposed to be the case, the upper two-thirds of the right and all the left kidney being behind the ribs. To mark them in from the front the following points should be noted: The upper extremity should reach as high up as the seventh costal cartilage, close to the costo-chondral junction. The lower end, about four and a half inches below this point, should be above a line drawn horizontally through the umbilicus, though it is to be remembered that the right often encroaches upon this line. Relatively to the vertebræ, the kidneys lie along the sides of the last thoracic and the first three lumbar. A vertical line carried up to the costal arch from the centre of Poupart's ligament has one-third of the kidney to its outer side, and two-thirds to its inner side, i.e. between this line and the median line of the body. The distance between the two kidneys and between each viscus and the middle line is thus given by Thane and Godlee: The position of the superior pole is indicated by a spot about two inches from the middle line, the hilum is placed at the same distance, and the inferior pole about two and a half to three inches from the middle line. The shortest distance between the two kidneys, 'at the upper part of their mesial borders,' measures about two and a half inches.

Fig. 689.—Transverse Section of the Abdomen through the Kidneys and Pancreas, at the level of the first Lumbar Vertebra. (Braune.)

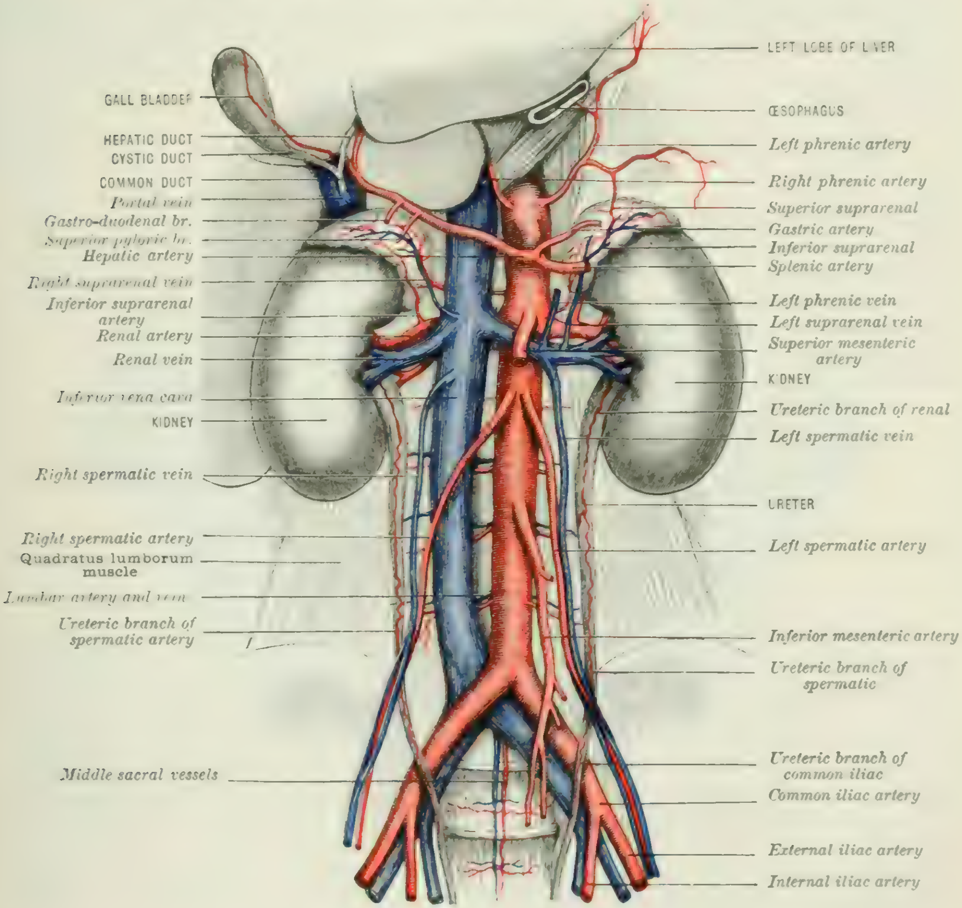

Inferior cava
Round ligament
TRANSVERSE COLON
Rectus
SEVENTH RIB
EIGHTH RIB
ASCENDING COLON
STOMACH
DUODENUM
SIGMOID FLEXURE
EIGHTH RIB
DESCENDING COLON
External oblique
Obliquus externus
PANCREAS
NINTH RIB
PLEURA
SPLEEN
TENTH RIB
KIDNEY
LIVER
Splenic vein
Diaphragm
Descending aorta
ELEVENTH RIB
BODY OF FIRST LUMBAR VERTEBRA
TWELFTH RIB
Psoas

On the posterior surface of the body the kidney's boundaries are indicated by the following:—(1) A line parallel with, and one inch from, the spine, between the lower edge of the tip of the spinous process of the eleventh thoracic and the lower edge of the spinous process of the third lumbar vertebra; (2) and (3) lines drawn from the top and bottom of this line outwards, at right angles to it, for two inches and three-quarters; (4) a line parallel to the first, and connecting (2) and (3). Within this parallelogram the kidney lies (Morris).

The spleen (figs. 588 and 589).—This lies very obliquely from above downwards, and from within outwards, in the left hypochondrium: thus its long axis corresponds closely with the line of the tenth rib. It is placed opposite the ninth, tenth, and eleventh ribs externally, being separated from these by the diaphragm; and internally it is connected with the great end of the stomach. Below, it overlaps slightly the outer border of the left kidney (figs. 690, 709, 710, and 711). Its highest point is on a level with the spine of the ninth thoracic, and its lowest with that of the eleventh thoracic vertebra. Its inner end is distant about an inch and a half from the median plane of the body, and its outer about reaches the mid-axillary line (Godlee). In the natural condition it cannot be felt; but if enlarged, its notched anterior margin extends downwards towards the umbilicus, and is both characteristic and readily felt.

Aorta and iliac arteries.—The aorta enters the abdomen opposite the last thoracic vertebra (a point five to six inches above the umbilicus, or rather above the mid-point between the infrasternal depression and the umbilicus (Thane and Godlee), and thence, lying to the left of the spine, divides into the two common iliacs opposite the disc between the third and fourth lumbar vertebræ, or opposite the body of the fourth lumbar vertebra. This point is about one inch below and to the left of the umbilicus, and on a level with a line drawn across the highest part of the iliac crest. A line drawn from this point, with a curve slightly outwards, to just within the centre of Poupart's ligament, will give the line of the iliac arteries; the first two inches (about) giving the average length of the common iliac.

FIG. 690.—THE ABDOMINAL AORTA AND INFERIOR VENA CAVA.


LEFT LOBE OF LIVER
GALL BLADDER
ŒSOPHAGUS
HEPATIC DUCT
Left phrenic artery
CYSTIC DUCT
COMMON DUCT
Right phrenic artery
Portal vein
Superior suprarenal
Gastro-duodenal br.
Gastric artery
Superior pyloric br.
Inferior suprarenal
Hepatic artery
Splenic artery
Right suprarenal vein
Left phrenic vein
Inferior suprarenal artery
Left suprarenal vein
Renal artery
Superior mesenteric artery
Renal vein
KIDNEY
Inferior vena cava
Ureteric branch of renal
KIDNEY
Left spermatic vein
Right spermatic vein
URETER
Right spermatic artery
Left spermatic artery
Quadratus lumborum muscle
Lumbar artery and vein
Ureteric branch of spermatic artery
Inferior mesenteric artery
Ureteric branch of spermatic
Ureteric branch of common iliac
Middle sacral vessels
Common iliac artery
External iliac artery
Internal iliac artery

The site of **some of the branches of the aorta** may be thus approximately remembered.

The **cœliac axis** is given off immediately after the aorta has perforated the diaphragm; directly below this is the **superior mesenteric artery.** About one inch lower down, or three inches above the umbilicus, the **renal arteries** are given off. About one inch above the umbilicus would be the level of the **inferior mesenteric artery.**

Collateral circulation after ligature of the common iliac.—The chief vessels here are:—

ABOVE.		BELOW.
Internal mammary and lower intercostals	with	Deep epigastric.
Lumbar	with	Ilio-lumbar and circumflex iliac.
Middle sacral	with	Lateral sacral.
Superior hæmorrhoidal	with	Inferior and middle hæmorrhoidal.

Collateral circulation after ligature of the external iliac:—

Deep epigastric	with	Internal mammary, lower intercostals, and lumbar.
Deep circumflex iliac	with	Ilio-lumbar, lumbar, and gluteal.
Gluteal and sciatic	with	Internal and external circumflex.
Comes nervi ischiadici	with	Perforating branches of profunda.
Obturator	with	Circumflex and epigastric.
Internal pudic	with	External pudic.

Collateral circulation after ligature of the internal iliac:—

Sciatic	with	Branches of profunda.
Hæmorrhoidal arteries	with	Inferior mesenteric.
Pubic branch of obturator	with	Vessel of opposite side.
Branches of pudic	with	Branches of opposite side.
Circumflex and perforating of profunda	with	Sciatic and gluteal.
Lateral sacral	with	Middle sacral.
Circumflex iliac	with	Ilio-lumbar and gluteal.

THE PERINÆUM AND GENITALS

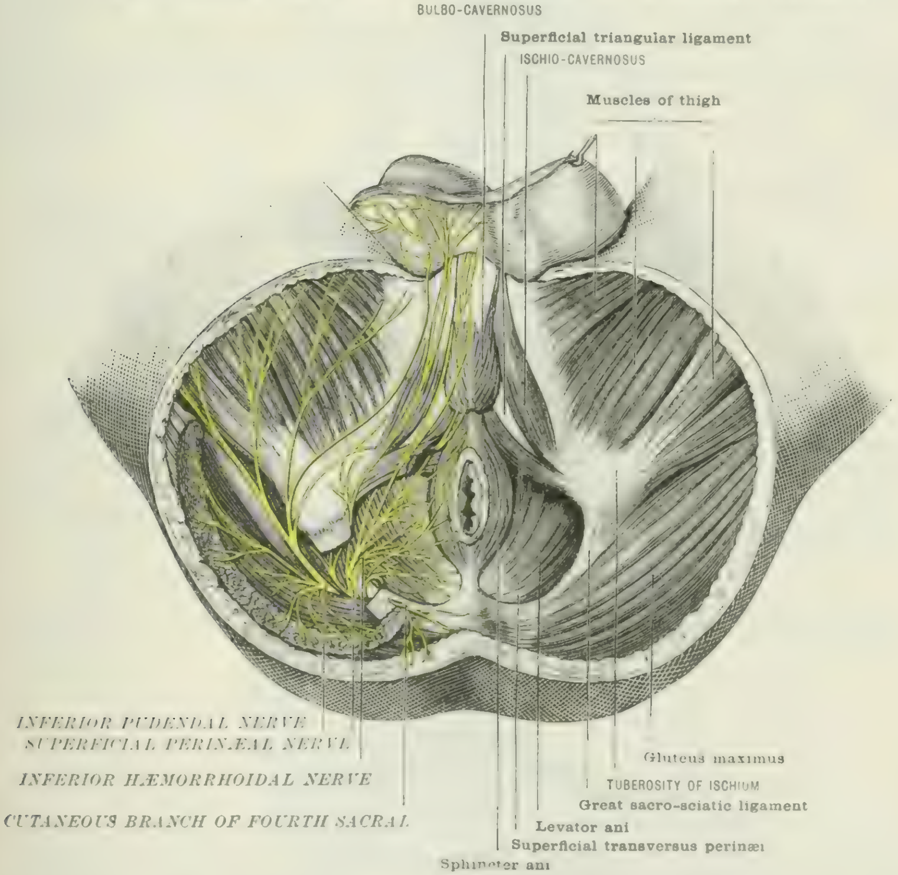
Bony boundaries.—These are the same in either sex. Above and in front is the symphysis pubis, rounded off by the subpubic ligament; diverging downwards and outwards from this point on either side are the rami of the pubes and ischium, ending at the tuberosities of the latter. In the middle line behind is the apex of the coccyx; and reaching from this to the tuberosities are the great sacro-sciatic ligaments, to be felt by deep pressure, with the lower border of the gluteus maximus overlapping them. The depth of the perinæum varies greatly, from two to three inches (30 to 75 mm.) in the posterior and outer part to one inch or less in front.

In the middle line, extending longitudinally through the perinæum, is the raphe, the guide to the urethra, and 'the line of safety' (on account of the small size of the vessels here) for operations on it.

An imaginary line drawn transversely across the perinæum from one tuber ischii to its fellow divides the lozenge-shaped space into **two triangles**—(1) An **anterior, or urethral**; and (2) a **posterior, or rectal.**

The **central point of the perinæum** is in the adult nearly an inch (25 mm.) in front of the anus, or midway between the centre of the anus and root of the scrotum. Here the following structures meet, viz., the sphincter ani, the two transverse perinæal muscles, the accelerator urinæ, and the levator ani. It also corresponds to the centre of the lower margin or base of the triangular ligament. Its development varies much in different bodies. A little in front of this point is the bulb, with the corpus spongiosum passing forwards from it. This would also be the level of the artery of the bulb, so that in lithotomy the incision should always begin below this point. A knife introduced at the central point, and carried backwards and very slightly upwards, should enter the membranous urethra just in front of the prostate. If pushed more deeply, it would enter the neck of the bladder. In **lateral lithotomy** the knife is entered an inch and a half (37 mm.) in front of the anus and carried downwards and outwards for two and a half or three inches (62 to 75 mm.) into the ischio-rectal fossa, ending a little below and external to the mid-point between the anus and tuber ischii. This incision begins deeply and ends more superficially. In the deeper part of the incision the knife is carried along the staff through the membranous urethra into the bladder. The parts divided in the operation are—skin, superficial fascia (both layers), transverse perinæal vessels and nerves, superficial perinæal vessels and nerves, inferior hæmorrhoidal vessels and nerves, transversus perinæi muscle, base of triangular ligament (anterior layer), membranous urethra and deep muscles, a venous plexus, posterior layer of triangular ligament, prostatic urethra, and left lobe of prostate and its capsule in part, with some of the fibres of the levator prostatæ. In median lithotomy, an incision an inch and a half long is made through the central tendinous point and raphe, so as to hit the membranous urethra. The following structures are divided:—Skin and fasciæ; some of the most anterior fibres of the sphincter ani; raphe and central tendinous point; minute branches of transverse perinæal vessels and nerves; base of triangular ligament in centre; membranous urethra and compressor urethræ.

FIG. 691.—THE MALE PERINÆUM. (Modified from Hirschfeld and Leveillé.)


BULBO-CAVERNOSUS
Superficial triangular ligament
ISCHIO-CAVERNOSUS
Muscles of thigh
INFERIOR PUDENDAL NERVE
SUPERFICIAL PERINÆAL NERVE
INFERIOR HÆMORRHOIDAL NERVE
CUTANEOUS BRANCH OF FOURTH SACRAL
Gluteus maximus
TUBEROSITY OF ISCHIUM
Great sacro-sciatic ligament
Levator ani
Superficial transversus perinæi
Sphincter ani

The attachments and arrangements of the **superficial fascia** (fig. 693) must be traced and remembered. Of the two layers of which it consists, the superficial alone extends over both urethral rectal triangles alike, and is continuous with the similar structures in adjacent regions, the only difference being that, if traced forwards into the scrotum and penis, it loses its fat, and contains dartos fibres. The deeper layer, found only over the urethral triangle, is called the fascia of Colles (fig. 693). Attached at the sides to the rami of the pubes, behind to the base of the triangular ligament, and open in front, it forms a somewhat triangular pouch, containing the superficial vessels, nerves, and muscles, the bulb, and adjacent part of the urethra. Owing to this space being closed behind and open in front, and to its containing the above structures, fluids extravasated within this space will obviously tend to make their way forwards into the scrotum, penis, and lower part of the abdominal wall.

The urethra.—This can be examined in part with the finger, but much better with the aid of a sound. The anterior, or penile, part is movable; the posterior, or deeper, more fixed. It is narrowest at the meatus and where the membranous urethra passes through the triangular ligament. It is widest in the prostatic part and the fossa navicularis. One of the most important landmarks is the triangular ligament, the base of which can just be felt in a thin perinæum. The membranous urethra passes through this, about three-quarters of an inch above the central point of the perinæum, about the same distance below the subpubic ligament, or an inch below the symphysis. Above the urethra run the dorsal vessels and nerves of the penis. The fixation, undilatability, surrounding muscular fibres, and close neighbourhood of a large amount of erectile tissue (the bulb), all account for difficulties in introducing instruments past this point. It is here also that the urethra is most liable to be damaged by a fall or blow. The attachment of the deep layer of superficial fascia to the base of the triangular ligament accounts for the fact that urine extravasated from a ruptured urethra, or through an opening behind a stricture, passes usually not backwards into the anal triangle, but forwards into the scrotum and abdominal wall. The other structures in relation with the triangular ligament are shown in fig. 693.

FIG. 692.—DEEP DISSECTION OF MALE PERINÆUM. (Roser.)

The bulb is slightly raised and the rectum drawn backwards, in order to make clear the membranous urethra and prostate, which are shown incised as in the lateral operation of lithotomy.

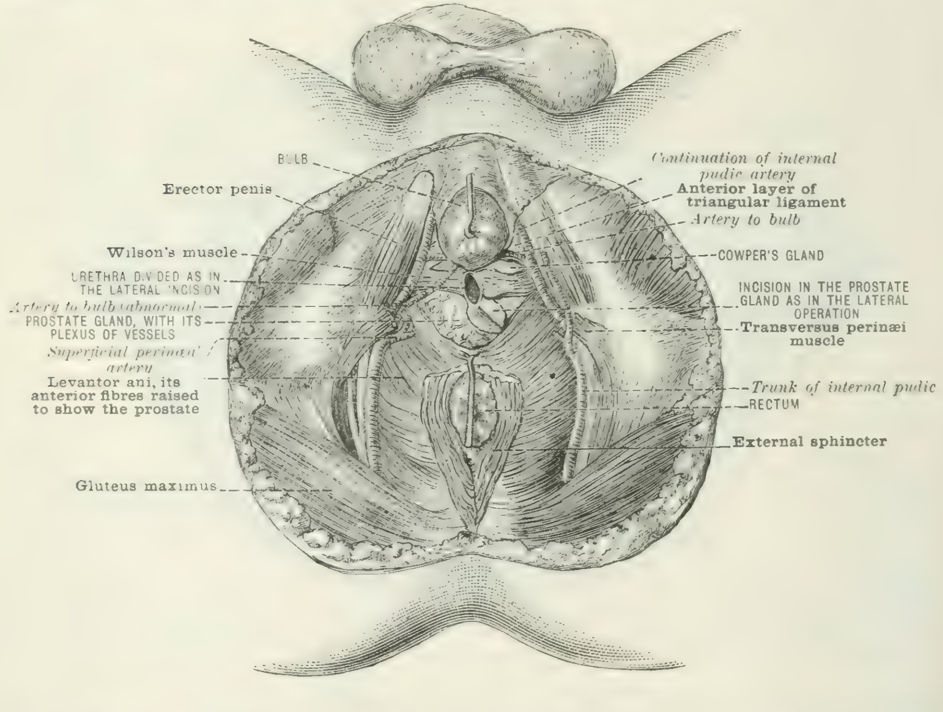

BULB
Erector penis
Wilson's muscle
URETHRA DIVIDED AS IN THE LATERAL INCISION
Artery to bulb (abnormal)
PROSTATE GLAND, WITH ITS PLEXUS OF VESSELS
Superficial perinæal artery
Levantor ani, its anterior fibres raised to show the prostate
Gluteus maximus
Continuation of internal pudic artery
Anterior layer of triangular ligament
Artery to bulb
COWPER'S GLAND
INCISION IN THE PROSTATE GLAND AS IN THE LATERAL OPERATION
Transversus perinæi muscle
Trunk of internal pudic
RECTUM
External sphincter

FIG. 693.—THE ARTERIES OF THE PERINÆUM.

On the right side of the perinæum (left side of this figure) Colles's fascia has been turned back to show the superficial vessels. On the left side the superficial vessels have been cut away with the anterior layer of the triangular ligament to show the deep vessels.

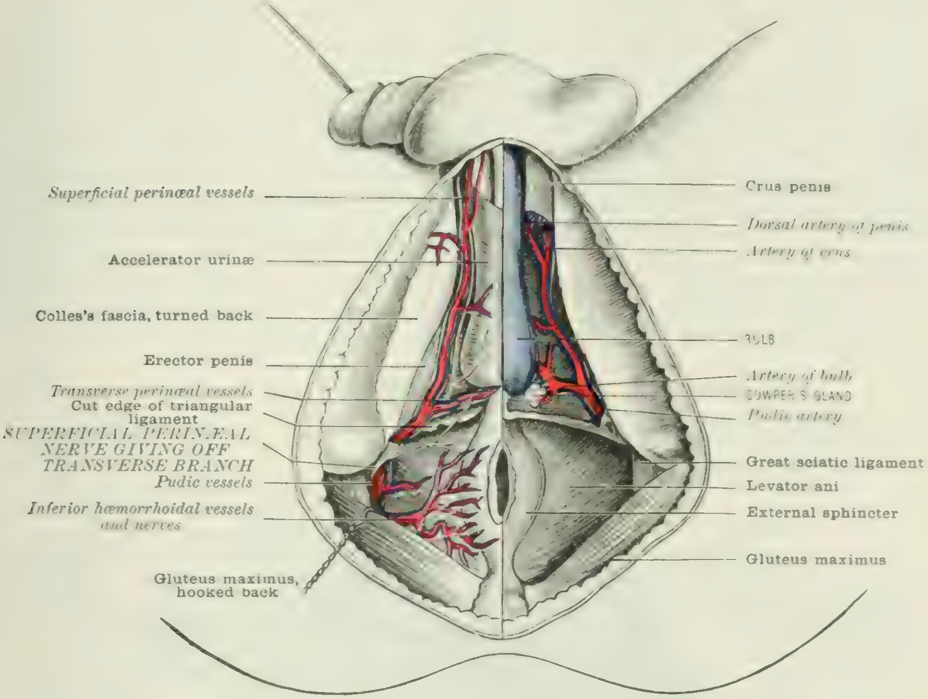
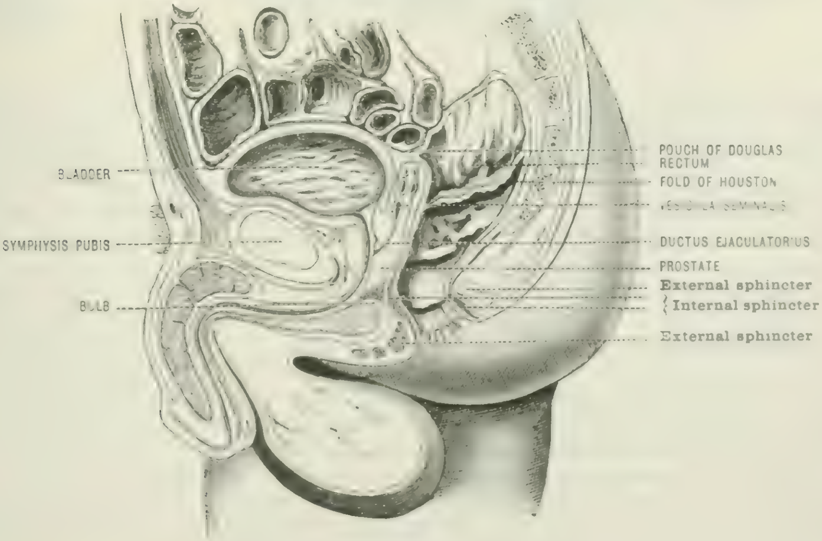
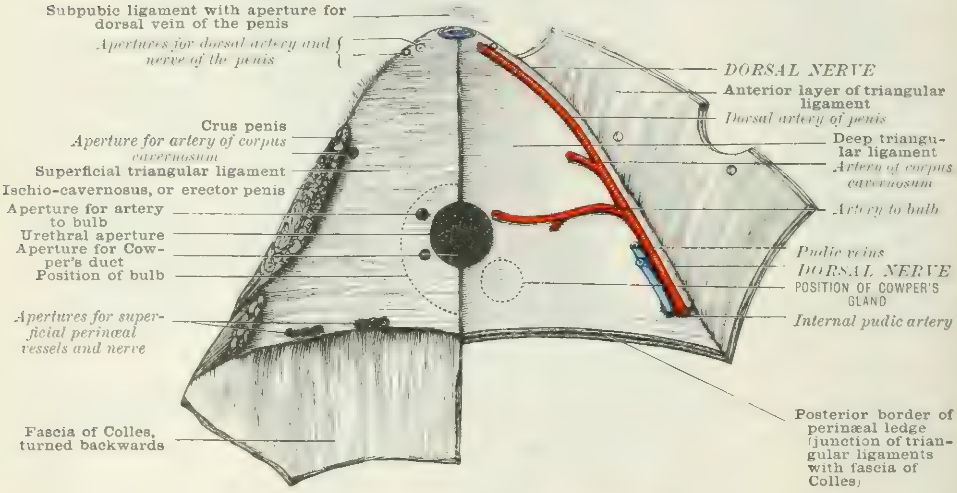

Superficial perinæal vessels
Accelerator urinæ
Colles's fascia, turned back
Erector penis
Transverse perinæal vessels
Cut edge of triangular ligament
SUPERFICIAL PERINÆAL NERVE GIVING OFF TRANSVERSE BRANCH
Pudic vessels
Inferior hæmorrhoidal vessels and nerves
Gluteus maximus, hooked back
Crus penis
Dorsal artery of penis
Artery of crus
BULB
Artery of bulb
COWPER'S GLAND
Pudic artery
Great sciatic ligament
Levator ani
External sphincter
Gluteus maximus

FIG. 694.—SAGITTAL SECTION OF MALE PELVIS IN THE MESIAL LINE. (One-third.) (Braune.)


BLADDER
SYMPHYSIS PUBIS
BULB
POUCH OF DOUGLAS
RECTUM
FOLD OF HOUSTON
VESICULA SEMINALIS
DUCTUS EJACULATORIUS
PROSTATE
External sphincter
Internal sphincter
External sphincter

The prostate (figs. 692 and 694).—The relations of this important organ should be studied, whenever possible, with the finger and sound. Roughly comparable to a chestnut in form, size, and dimensions, its base, situated below the neck of the bladder, blends by its muscular tissue with this organ. As the long axis of the prostate is very oblique, the base will be directed upwards and backwards (fig. 694). The apex, resting against the upper or deeper layer of the triangular ligament, lies about half an inch behind the subpubic angle. This part of the organ can be detected by the finger about one and a half inches above the anal orifice, through the anterior wall of the rectum. Continuous with this, and a little higher up, the posterior surface can also be made out through the second part of the bowel. The anterior surface receives the pubo-prostatic ligaments, and on this surface lies the greater part of the prostatic plexus (fig. 696). The lateral margins of the gland are embraced by the anterior borders of the levatores ani. The urethra, in its course through the organ from base to apex in the middle line, lies rather nearer to the anterior than the posterior surface. The ejaculatory ducts, as they pass obliquely through the prostate to open at the margins of the sinus pocularis, mark off a portion of the gland which lies between each duct below and the neck of the bladder above (fig. 694). It is obvious that, if this portion be enlarged, obstruction to the escape of urine from the bladder must follow. Up to puberty, the prostate is imperceptible per rectum. In adolescence the organ, while to be felt, is softer and more rounded, and lacks the character and shape which distinguish the organ in adult life. The capsule (fig. 696) of the organ must be remembered. It is formed by a layer from the recto-vesical fascia, and under it, especially on its anterior and lateral aspects (fig. 696), lies the prostatic plexus, formed chiefly by the breaking up of the dorsal vein of the penis.

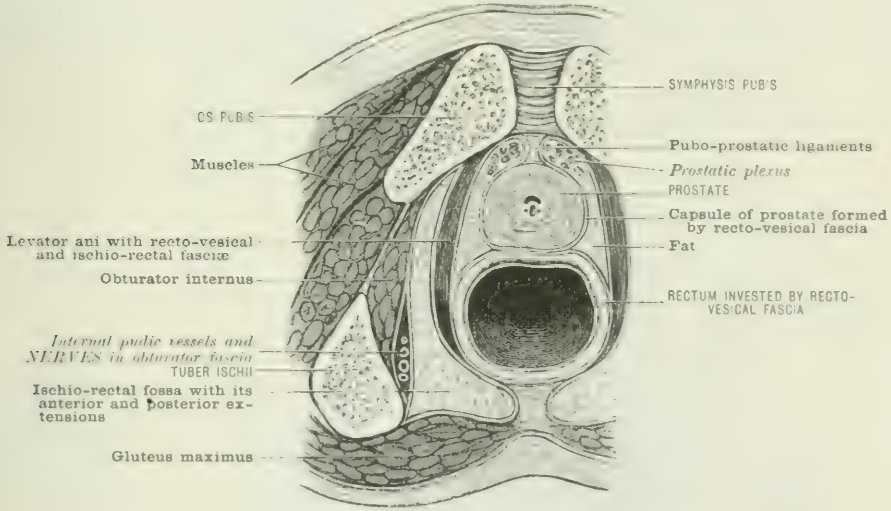
Fig. 695.—Scheme of the Pudic Artery and its Branches.


Subpubic ligament with aperture for dorsal vein of the penis
Apertures for dorsal artery and nerve of the penis
Crus penis
Aperture for artery of corpus cavernosum
Superficial triangular ligament
Ischio-cavernosus, or erector penis
Aperture for artery to bulb
Urethral aperture
Aperture for Cowper's duct
Position of bulb
Apertures for superficial perinæal vessels and nerve
Fascia of Colles, turned backwards
DORSAL NERVE
Anterior layer of triangular ligament
Dorsal artery of penis
Deep triangular ligament
Artery of corpus cavernosum
Artery to bulb
Pudic veins
DORSAL NERVE
POSITION OF COWPER'S GLAND
Internal pudic artery
Posterior border of perinæal ledge (junction of triangular ligaments with fascia of Colles)

The continuity of the above sheath of the prostate with the recto-vesical fascia on the upper surface of the levator ani and the sides of the bladder forms the roof of the perinæum and part of the floor of the pelvis. If by mistake an incision, as in lithotomy, is carried through this prostatic sheath, the cavities of the pelvis will be opened and extravasation of fluids into the connective tissue, which everywhere follows the layers of pelvic fascia, will follow. Before leaving the **relations of the prostate,** the reader should consider the **layers which will be met with in cutting down to this organ from the surface.** The following fasciæ and muscular layers will be met with alternately (Cunningham): (1) Skin and superficial fascia; (2) fascia of Colles; (3) superficial perinæal muscles; (4) superficial layer of triangular ligament; (5) compressor urethræ; (6) deep layer of triangular ligament; (7) levator ani; (8) capsule of prostate. Further, these fasciæ of the urethral triangle (p. 1123) are so arranged as to form a **superficial deep compartment,** and within one or other of these all the structures of this most important division of the perinæum are found. Thus the **superficial compartment** is bounded, in front, by the fascia of Colles; behind, by the triangular ligament; laterally, by the attachment of these to the margins of the pubic arch; and, behind, by the blending of the fascia of Colles with the base of the triangular ligament. The contents of this compartment are given elsewhere. The **deeper compartment** is the interval between the two layers of the triangular ligament.

Ischio-rectal fossa.—Most of the boundaries of this space (p. 1063) can be made out with the finger in a thin subject. The loose, poorly vitalised fat which occupies it, the dependent position of the part, its terminal blood-supply, its exposure to cold and damp, and the close vicinity of decomposing fæces, all account for the frequency of abscess here. The position of the pudic vessels and nerve in their sheath of obturator fascia, on the outer wall, about an inch and a half above the lower margin of the tuber ischii, must be remembered.

FIG. 696.—SECTION SHOWING THE ISCHIO-RECTAL FOSSA IN ITS RELATIONS TO THE PELVIC VISCERA.


SYMPHYSIS PUBIS
OS PUBIS
Pubo-prostatic ligaments
Muscles
Prostatic plexus
PROSTATE
Capsule of prostate formed by recto-vesical fascia
Levator ani with recto-vesical and ischio-rectal fasciæ
Fat
Obturator internus
RECTUM INVESTED BY RECTO-VESICAL FASCIA
Internal pudic vessels and NERVES in obturator fascia
TUBER ISCHII
Ischio-rectal fossa with its anterior and posterior extensions
Gluteus maximus

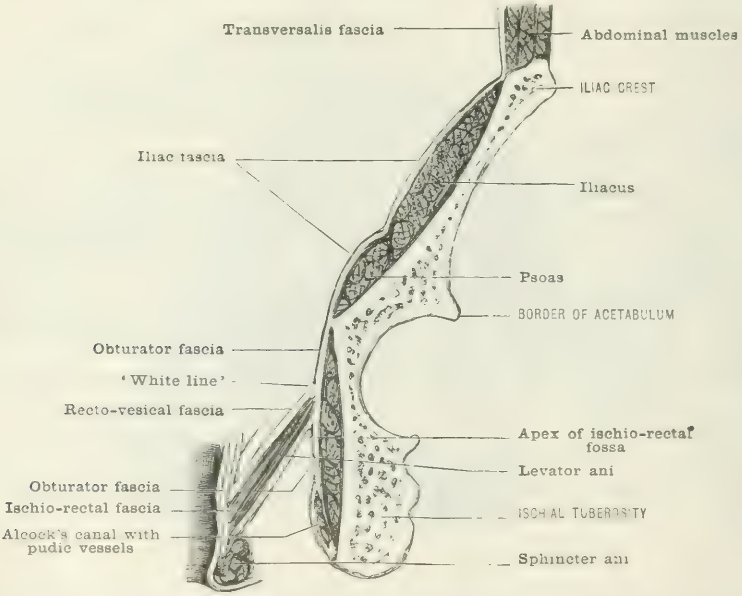
Anus.—The tightly closed condition of this orifice in health and the puckering of the skin around, due to the sphincter and corrugator cutis ani, are characteristic. Dilated veins, external piles, or tags of skin resulting from the shrinking of these, are also common. A white line, varying in distinctness in different subjects, marks the junction of the skin and mucous membrane, and the interval between the external and internal sphincters (Hilton). Amongst the numerous folds about the anal orifice, a fissure or ulcer may be hidden, especially on the coccygeal aspect; the abundant nerve-supply to this region and the large distribution of the pudic nerve to the genitals, and the junction of this nerve with other branches of the sacral plexus, explain the acuteness of the suffering, and its wide distribution in these affections (Hilton).

Rectum.—The following points can be made out by the finger introduced here: (1) The thickened, roll-like feel of a contracted external sphincter; (2) the narrower, more expanded, internal sphincter extending upwards for an inch from this; (3) the condition of the ischio-rectal fossæ on either side; (4) the membranous urethra in front, especially if a staff has been introduced; (5) just beyond the sphincters, or an inch and a half within the anus, lies the prostate; (6) converging towards the base of the prostate, and forming the sides of the triangular space, are the vesiculæ seminales and ejaculatory ducts. These can rarely be felt unless diseased and enlarged; (7) it is within this triangular space that a distended bladder can be felt, and, if the prostate is not enlarged, punctured, the trocar being driven in the direction of the long axis of the distended viscus, i.e. towards the umbilicus. As a rule, the recto-vesical pouch is reflected at a distance of three and a half or even four inches (87 to 100 mm.) from the anus. In the female the distance is only three inches, or even less. (8) Sometimes the lowest of the folds of Houston, on about the same level as the prostate, semilunar in form and about half an inch in width, can be made out (fig. 694).

The position of this and the other two folds of Houston should be remembered, as their presence, if well developed and if the bowel be empty, may interfere with the passage of instruments.

In addition to the **structures which can be felt, those which can be seen with a speculum,** especially if the body be seen in the semiprone or genu-pectoral position, must be noted. Starting from immediately within the anus are some six or eight vertical folds of mucous membrane, the columns of Glisson. Between these columns lie little pockets or lacunæ, the sinuses of Morgagni, just above the external sphincter. In the above-mentioned columns the hæmorrhoidal vessels ascend and descend, intercommunicating by numerous transverse branches.

FIG. 697.—DIAGRAM OF THE PELVIC FASCIÆ.


Transversalis fascia
Abdominal muscles
ILIAC CREST
Iliac fascia
Iliacus
Psoas
BORDER OF ACETABULUM
Obturator fascia
'White line'
Recto-vesical fascia
Apex of ischio-rectal fossa
Levator ani
Obturator fascia
Ischio-rectal fascia
ISCHIAL TUBEROSITY
Alcock's canal with pudic vessels
Sphincter ani

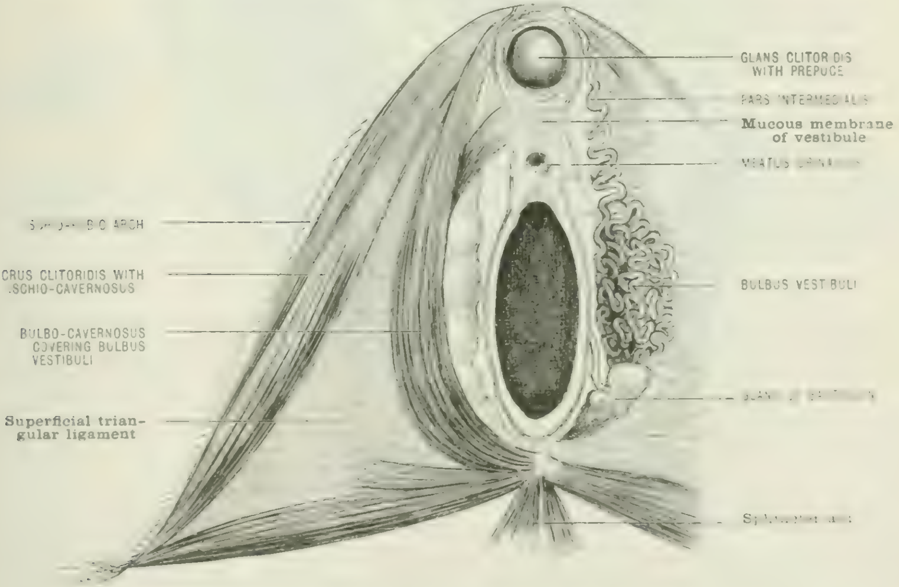
The above examination refers chiefly to the male. It remains to refer to **rectal examination in the female.** Anteriorly, the soft perinæal body and recto-vaginal septum will be met with, and, through the latter, the cervix and os uteri, and, higher up, the lower part of the cervix uteri. More laterally the ovaries may be felt, but the Fallopian tubes, unless enlarged and thickened, are not to be made out. The student should be familiar with the feel of a healthy recto-uterine or recto-vesical pouch, according to the sex, and the coils of intestine which it may contain, so as to be able to contrast this with any collection of inflammatory or other fluid or mischief descending from the upper pelvis, e.g. from the vermiform appendix. Posteriorly, certain structures are met with in either sex. After a very short interval (sphincter and ano-coccygeal body), the finger reaches the tip of the coccyx and explores the hollow of the sacrum. On each side is the ischial tuberosity and wall of the true pelvis. The finger, hooked outwards and upwards, comes on the border of the falciform process of the great sacro-sciatic ligament passing between the above-mentioned bones.

The **pelvic fascia** and its chief layers are shown in fig. 697. These are described at page 1060. The following main points will readily be seen: That the fascia has one important aspect towards the pelvic, and another towards the ischio-rectal fossa and perinæum, and thus may be interfered with during operations, or affected by inflammation arising in either region. That its numerous processes and sheaths, while they serve to isolate different structures, are continuous, and that thus septic mischief may, as in the neck, spread most widely. With this fact go two other points: one, that with the planes of this fascia run layers of connective tissue; the other, that in the spaces tightly girt by this fascia lie large venous plexuses, e.g. vesical, hæmorrhoidal, prostatic, and, if septic mischief reach these plexuses, it is out of reach of surgical treatment. The closeness of the fascia to the hip-joint will also be seen. In children with a thin acetabulum and hip disease this fascia becomes much thickened, thus shutting off the pelvic cavity from suppuration in the joint.

FEMALE EXTERNAL GENITALS

Under the above heading are included, for convenience sake, the labia majora and minora at the sides; and, in the middle line, from above downwards:—(1) The glans clitoridis with its prepuce; (2) the vestibule; (3) the urethral orifice; (4) the vaginal orifice with the hymen or its remains; (5) the fossa navicularis; (6) the fourchette; (7) the skin over the base of the perinæal body.

Fig. 698.—Diagrammatic Representation of the Perinæal Structures in the Female.


GLANS CLITORIDIS WITH PREPUCE
PARS INTERMEDIALIS
Mucous membrane of vestibule
MEATUS URINARIUS
SUBPUBIC ARCH
CRUS CLITORIDIS WITH ISCHIO-CAVERNOSUS
BULBUS VESTIBULI
BULBO-CAVERNOSUS COVERING BULBUS VESTIBULI
GLAND OF BARTHOLIN
Superficial triangular ligament
Sphincter ani

These parts have been described elsewhere, and only those points which are of importance in a clinical examination will be alluded to here.

The **labia majora** are two thick folds of skin, covered with hair on their outer surface, especially above where they unite (*anterior commissure*) in the mons Veneris. They contain fat, vessels, and dartos, but become rapidly thinner below, where they are continuous with the fourchette in front of the perinæum (their *posterior commissure*).

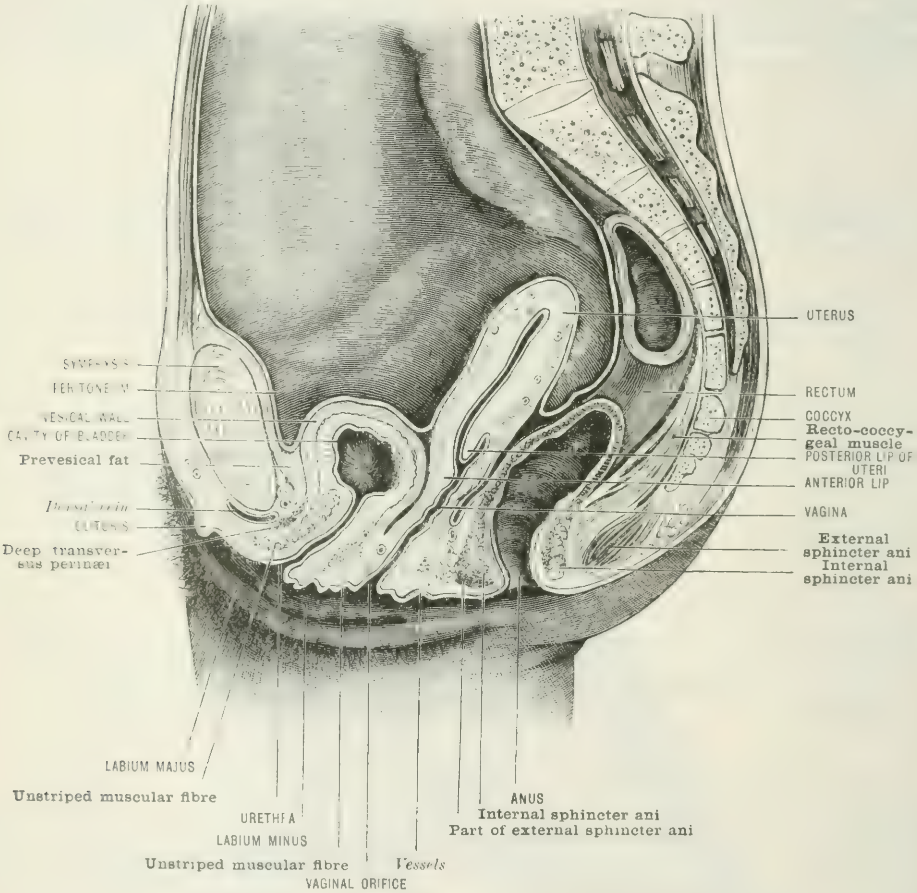
When the above folds are drawn aside, the **labia minora**, or **nymphæ**, appear, not projecting, in a healthy adult, beyond the labia majora. They are small folds of skin, which meet above in the prepuce of the clitoris, and below blend with the labia majora about their centre.

The glans clitoridis, covered by its prepuce, occupies the middle line above.

Below it comes the **vestibule**, a triangular smooth surface of mucous membrane, bounded above by the clitoris, below by the upper margin of the vaginal orifice, and laterally by the labia minora. In the middle line of the vestibule and towards its lower part, about half an inch (12 mm.) below the glans clitoridis, and an inch (25 mm.) above the fourchette, is the meatus or opening of the urethra (figs. 698, 699).

The **vaginal orifice** lies in the middle line between the base of the vestibule above, and the fossa navicularis below. Its orifice is partially closed in the virgin by a fold of mucous membrane, the **hymen** (fig. 631). This is usually crescentic in shape, attached below to the posterior margin of the vaginal orifice, and with a free edge towards the base of the vestibule. In some cases it is diaphragmatic, i.e. attached all around, but perforated in the centre (fig. 698).

FIG. 699.—SECTION OF THE FEMALE PELVIS. (After Henle.)


SYMPHYSIS
PERITONEUM
VESICAL WALL
CAVITY OF BLADDER
Prevesical fat
Dorsal vein
CLITORIS
Deep transversus perinæi
UTERUS
RECTUM
COCCYX
Recto-coccygeal muscle
POSTERIOR LIP OF OS UTERI
ANTERIOR LIP
VAGINA
External sphincter ani
Internal sphincter ani
LABIUM MAJUS
Unstriped muscular fibre
URETHRA
LABIUM MINUS
Unstriped muscular fibre
Vessels
VAGINAL ORIFICE
ANUS
Internal sphincter ani
Part of external sphincter ani

The shrivelled remains of the hymen probably constitute the **carunculæ myrtiformes.** On either side of the vaginal orifice, at its lower part, lie the racemose, muciparous glands of Bartholin, situated beneath the superficial perinæal fascia and sphincter vaginæ. Their ducts run slightly upwards and open, external to the attachment of the hymen, within the labia minora.

Fourchette and fossa navicularis.—The fourchette, as stated above, is the lower commissure of the labia majora. Normally the inner aspect of this is in contact with the lower surface of the hymen. When the fourchette is pulled down by the finger, a shallow depression is seen, the **fossa navicularis**, with the fourchette for its posterior, and the hymen for its anterior boundary.

Examination per vaginam.—The finger, introduced past the gluteal cleft, perinaeum, and fourchette, comes upon the elliptical orifice of the vagina, and notes how far it is patulous or narrow; the presence or otherwise of any spasm from the adjacent muscles; then, passing into the canal itself, the presence or absence of rugae, a naturally moist, or a dry condition are observed. In the anterior wall the cord-like track of the urethra can be detected; and further up than this, if a sound be passed, the posterior wall of the bladder. The anterior wall of the vagina is two to two and a half inches long. The posterior wall, three inches long, forms the recto-vaginal septum, and through it any faeces present in the bowel are easily felt. The cervix uteri is next felt for in the roof of the vagina, projecting downwards and backwards in a line drawn from the umbilicus to the coccyx. Besides its direction, its size, shape, mobility, and consistence should be noted. The os uteri should form a dimple or fissure in the centre of the cervix. Of its two lips the posterior is the thicker and more fleshy feeling of the two. The vaginal *culs-de-sac* or fornices are next explored. These should be soft and elastic, giving an impression to the finger similar to that when it is introduced into the angles of the mouth. Any resistance felt here may be due to scars, swellings connected with the uterus (displacements, or myomata), effusions of blood or inflammatory material, and, in the case of the lateral *culs-de-sac*, a displaced or enlarged ovary, or dilatations of the Fallopian tubes.

HERNIA

PARTS CONCERNED IN INGUINAL HERNIA

In inguinal hernia, as in femoral and umbilical, there is a weak spot in the abdominal wall—one weakened for the needful passage of the testicle from within to outside the abdomen. The parts immediately concerned are the two abdominal rings, external and internal, and the canal. Now, it must be remembered at the outset that the rings and canal are only potential—they do not exist as rings or canal save when opened up by a hernia, or when so made by the scalpel. The canal is merely an oblique slit or flat-sided passage. The external and internal rings are so intimately blended with the structures that pass through them, and so filled by them, that they are potential rings only.

EXTERNAL RING.—This is usually described as a ring: it is really only a separation or gap in the aponeurosis of the external oblique, by which in the male the testicle and cord, and in the female the round ligament by which the uterus is kept tilted a little forwards, pass out from the abdomen. The size of this opening, the development and strength of its sides or pillars, the fascia closing the ring—all vary extremely. **Formation**: by divergence of two fasciculi of the external oblique aponeurosis. **Boundaries**: two pillars—(1) Internal, the smaller, attached to the symphysis and blending with the suspensory ligament of the penis; (2) external, stronger, attached to the pubic spine and blending with Poupart's ligament, and so with the fascia lata. On this outer, stronger pillar rests the cord (and so the weight of the testicle), or round ligament. **Shape**: triangular or elliptical, with the base downwards and inwards towards the pubic crest.

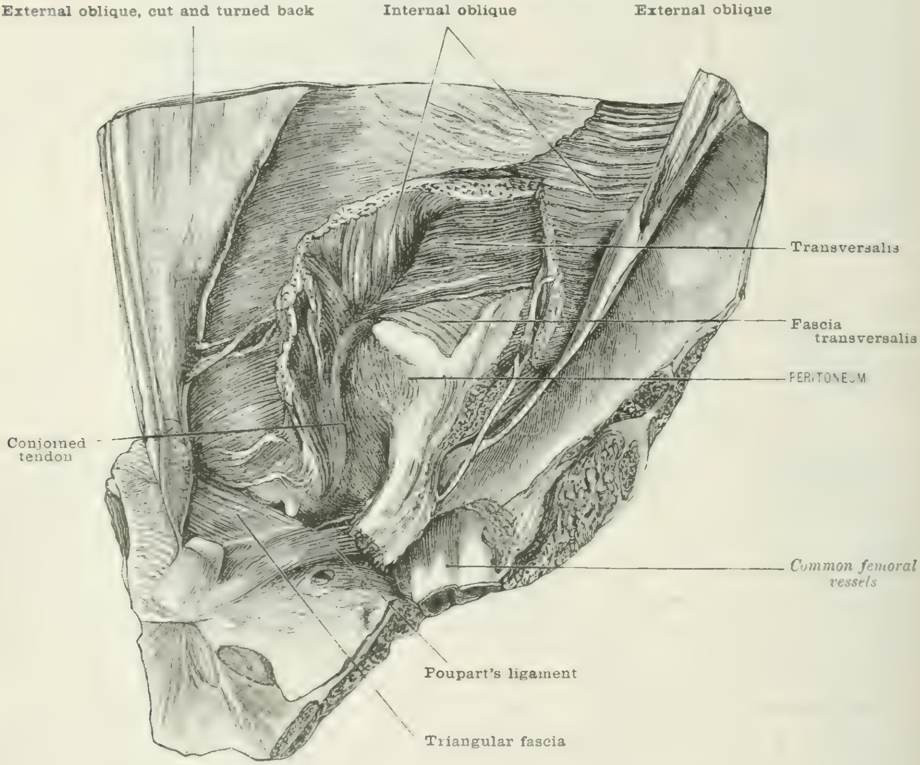
Intercolumnar fascia. External spermatic fascia.—This, derived from the lower part of the aponeurosis of the external oblique, ties the two pillars together, and, being continued over the cord, prevents there being any ring here, unless made with a scalpel. This is the rule in the body: when any structure passes through an opening in a fibrous or muscular layer, it carries with it a coating of tissue from that layer; e.g. the inferior cava passing through the foramen quadratum in the diaphragm, and the membranous urethra through the triangular ligament.

Effect of position of the thigh on the ring.—As the lower pillar is blended with Poupart's ligament, and as the fascia lata is connected with this, movements of the thigh will affect the ring much, making it tighter or looser. Thus extension and abduction of the thigh stretch the pillars and close the ring. In flexion and adduction of the thigh the pillars are relaxed; and this is the position in which reduction of a hernia is attempted. In flexion and abduction of the thigh, the ring is open; and this is the position in which a patient should sit, to try on a truss, and cough. If the hernia is now kept up, the truss is satisfactory.

Helping to protect this most important spot, and preventing its being more than a potential ring, are not only the two pillars, and the intercolumnar fascia, but also a structure which has been called a third or posterior pillar, namely, the **triangular fascia.** This has its base above at the lower part of the linea alba, where it joins its fellow and the aponeurosis of the external oblique, and its apex downwards and outwards, where, having passed behind the internal pillar, it blends with Gimbernat's ligament. Again, the conjoined tendon of the internal oblique and transversalis curving inwards and downwards to be attached to the ilio-pectineal line and spine is a most powerful protection, behind, to what is otherwise a weak spot and a potential ring.

FIG. 700.—THE PARTS CONCERNED IN INGUINAL HERNIA.

(From a dissection in the Hunterian Museum.)



INGUINAL CANAL.—This is not a canal in the usual sense, but a chink or flat-sided passage in the thickness of the abdominal wall. The descriptions of the canal usually given apply rather to the diseased than to the healthy state. It was a canal once, and for a time only, i.e. in the later months of fœtal life. It remains weak for a long time after, but only a vestige of it remains in the well-made adult. On the inner surface of the abdomen we have a few inconspicuous inguinal fossettes; on the outer surface a separation between the fasciculi of the external oblique, carefully closed and protected; in the interval between the two surfaces lies the cord or round ligament, in the thickness of the abdominal wall.

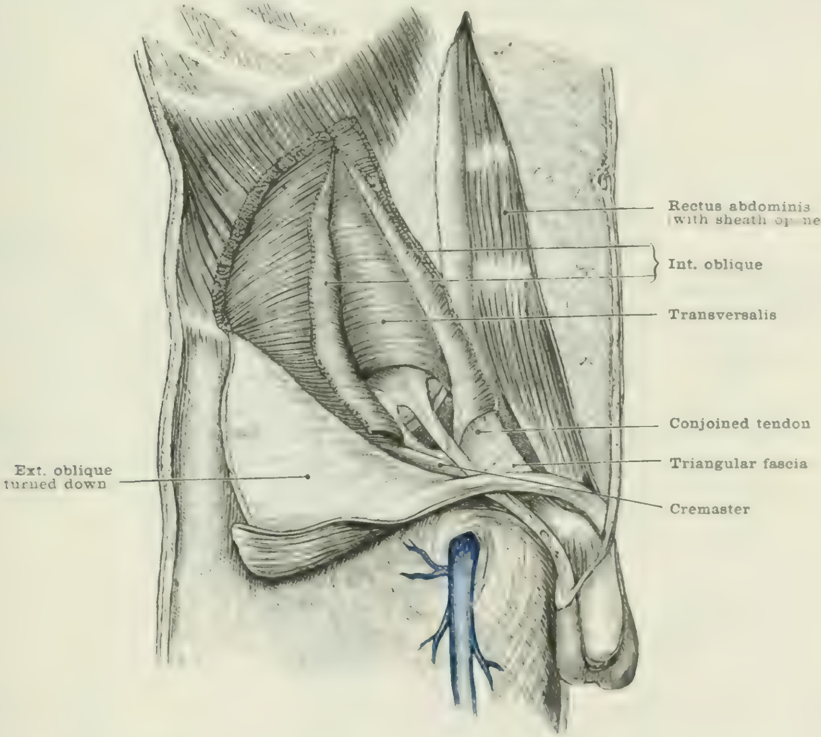
Length.—In very early life there is no canal; one ring lies directly behind the other, so as to facilitate the easy passage of the testis. In the adult it measures about an inch and a half (37 mm.) in length, this lengthening being brought about by the growth and separation of the alæ of the pelvis. This increased obliquity gives additional safety.

Direction.—From internal to external ring, downwards, forwards, and inwards.

Boundaries.—For convenience sake, certain limits (largely artificial) have been named—

(1) *Floor.*—This is best marked near the outlet, where the cord rests on the grooved upper margin of Poupart's ligament. The meeting of the transversalis fascia with this ligament forms the floor.

FIG. 701.—DISSECTION OF INGUINAL CANAL. (Wood.)



(2) *Roof.*—The apposition of the muscles and the arched border of the internal oblique and transversalis.

(3) *Anterior wall.*—Skin, superficial fascia, external oblique for all the way. Internal oblique, i.e. that part arising from Poupart's ligament, for the outer third or so.

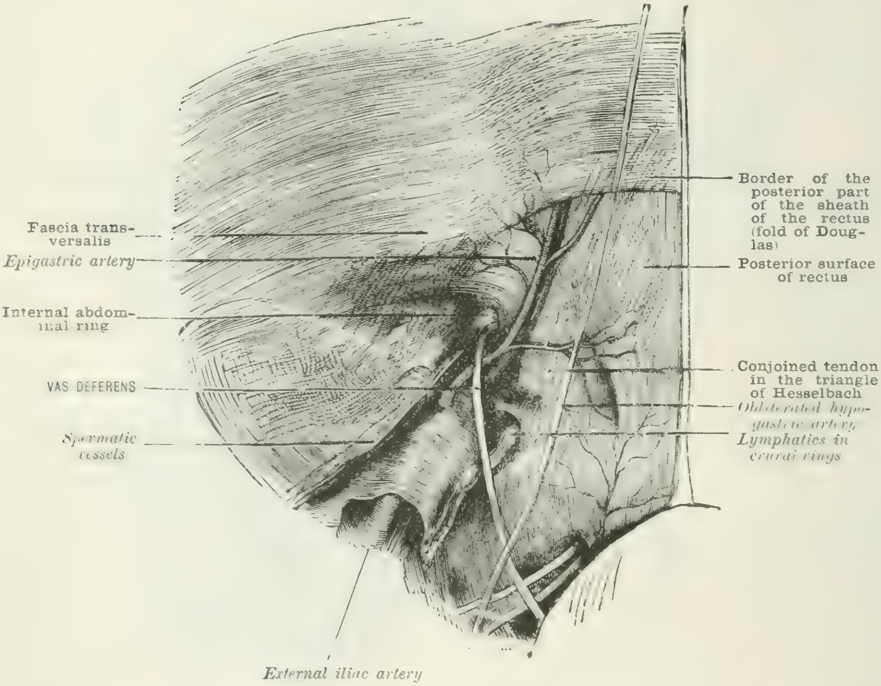
(4) *Posterior wall.*—For the whole extent, transversalis fascia, extra-peritoneal tissue, and peritoneum. For the inner two-thirds, conjoined tendon of internal oblique and transversalis, and the outer edge of the triangular fascia, when developed. Of the structures forming the posterior wall, the transversalis fascia is the strongest. It is thicker and better marked at its attachments below; these are —(*a*) externally, to inner lip of iliac crest; (*b*) to Poupart's ligament between the anterior superior spine and the femoral vessels; here it joins the fascia iliaca; (*c*)

opposite the femoral vessels it also joins the fascia iliaca, and forms with it a funnel-shaped sheath; (*d*) internal to the femoral vessels the fascia transversalis is attached to the ilio-pectineal line, behind the conjoined tendon, with which it blends.

INTERNAL RING.—It has already been said that the term 'ring' is here misapplied except in an artificial sense, as when an opening is made by a scalpel; or in a pathological one, as when a hernia is making its way by opening up the parts. The terms 'internal' and 'external' are also misapplied as far as their usual application to the middle line of the body is concerned. The terms apply to depth only. The 'internal ring' is not a ring in the least, but merely a funnel-shaped expansion of the transversalis fascia, which the cord carries on with it as it escapes from the abdomen. This expansion may be weakened, but it is never an opening save when made so artificially.

Site.—Midway between the anterior superior spine and spine of pubes. **Shape:** oval, with the long diameter upwards. **Dimensions:** one inch (25 mm.) by half an inch. Both these are artificial. **Boundaries:** centre of Poupart's ligament, about half an inch below. Internally, the deep epigastric artery (fig. 702); and thus the inner side seems to be better defined. But the outer side is really the better defined, as here the transversalis fascia is descending to Poupart's ligament, to form the deep 'crural' arch, and to help to close in the great gap or notch between Poupart's ligament and the innominate bone. Owing to the artery lying to the inner side, the incision, in cutting to relieve the deep constriction of an inguinal hernia, should always be made directly upwards, so as to avoid the above vessel.

FIG. 702.—DISSECTION OF THE LOWER PART OF THE ABDOMINAL WALL FROM WITHIN, THE PERITONEUM HAVING BEEN REMOVED. (Wood.)


Fascia transversalis
Epigastric artery
Internal abdominal ring
VAS DEFERENS
Spermatic vessels
Border of the posterior part of the sheath of the rectus (fold of Douglas)
Posterior surface of rectus
Conjoined tendon in the triangle of Hesselbach
Obliterated hypogastric artery
Lymphatics in crural rings
External iliac artery

Coverings.—There are two chief forms of inguinal hernia:—

A. **The common form: external, or oblique.**—**External,** because it appears (at the internal ring) external to the deep epigastric artery. **Oblique,** because it traverses the whole of the inguinal canal, entering it at its inlet and leaving it at its outlet.

B. **Rarer form: internal, or direct.**—**Internal,** because it appears internal to the deep epigastric artery. **Direct,** because, instead of making its way down the whole oblique canal, it comes by a short cut, as it were, only into the lower part of the canal, and then emerges by the same opening as the other.

A. **Oblique, external inguinal hernia.**—This contains its **coverings** as follows:—

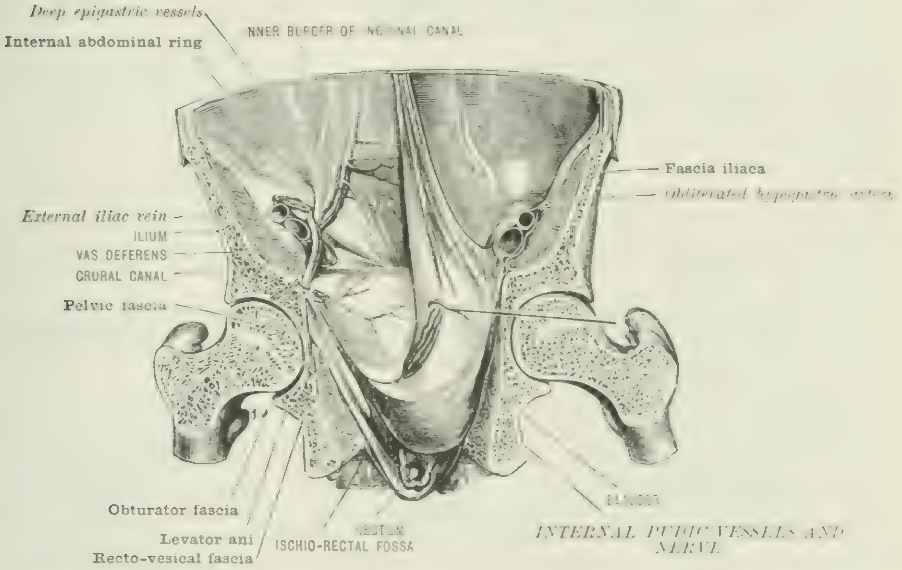
(1) **At the internal ring,** or **inlet,** it obtains three:—(*a*) Peritoneum; (*b*) extra-peritoneal fat; (*c*) infundibuliform fascia, or the layer of transversalis fascia prolonged at this spot along the cord.

(2) **In the canal** it obtains one. As it emerges beneath the lower border of the internal oblique, it gets some fibres from the cremaster.

(3) **At the external ring,** or **outlet,** the hernia obtains three, viz.: (*a*) Intercolumnar fascia; (*b*) superficial fascia; and (*c*) skin.

B. **Direct or internal inguinal hernia.**—This does not come through the internal ring, but, making its way through the posterior wall of the lower third of the canal—i.e. the conjoined tendon, either pushing this forward or splitting it—gets its **coverings** only from structures in relation to this part of the canal. They are—(1) Peritoneum; (2) extra-peritoneal fat; (3) transversalis fascia (not the specialised part at the internal ring or infundibuliform fascia); (4) conjoined tendon of internal oblique and transversalis. At the outlet of the external ring the coverings obtained are the same as in the oblique hernia, viz. (5) intercolumnar fascia; (6) superficial fascia; (7) skin.

FIG. 703.—VERTICAL SECTION OF PELVIS PASSING THROUGH THE HEADS OF THE THIGH BONES. (Blandin.)


Deep epigastric vessels
Internal abdominal ring
INNER BORDER OF INGUINAL CANAL
Fascia iliaca
obliterated hypogastric artery
External iliac vein
ILIUM
VAS DEFERENS
CRURAL CANAL
Pelvic fascia
Obturator fascia
Levator ani
Recto-vesical fascia
RECTUM
ISCHIO-RECTAL FOSSA
INTERNAL PUDIC VESSELS AND NERVE

Hitherto the two forms of inguinal hernia have been considered from the **superficial aspect,** that in which they are met with in practice. The inguinal region should also be studied as to the **posterior aspect** of its so-called rings and canal, as these have to bear the early stress of a commencing hernia. It is against this aspect that a piece of omentum or intestine is constantly and insidiously pressing, and endeavouring to make its way out. Furthermore, when either of the above constituents of hernia have made their way a little farther, and got out into the internal ring or into the canal, the patient is no longer sound.

On the posterior wall are certain cords and depressions, marking off regions which correspond to those on the surface.

Thus, there are three prominent **cords,** and three **fossæ.**

Three cords—(1) Median, or **urachus**; (2) lateral, or the **obliterated hypogastric arteries.**

(1) Median, or urachus. This interesting fœtal relic, the intra-abdominal part of the allantois, passes up between the apex of the bladder and the umbilicus, and by so doing—(*a*) keeps the bladder up, especially in early life, when the pelvic cavity is but little developed; (*b*) it keeps the bladder well up so that it shall be above the level of the urethra, and so more easily emptied; (*c*) it provides, by thus keeping up the bladder, that it shall enlarge in a direction which will admit of the greatest amount of distension, i.e. one between the lower or yielding part of the abdominal wall and the hollow of the rectum, which is compressible.

(2) The obliterated hypogastric arteries. These, the remains of vessels which during fœtal life carry the impure blood of the fœtus out to the mother through the umbilicus, run up and join the urachus at the umbilicus. In relation to these cords are the following **fossæ**: (*a*) An **internal** one, between the urachus and the obliterated hypogastric artery. This corresponds, on the anterior surface, to the external abdominal ring. Through this fossa comes direct inguinal hernia. (*b*) Between the obliterated hypogastric artery and the deep epigastric artery, running upwards and inwards to form the outer boundary of Hesselbach's triangle, is a **middle fossa.** This is the smallest of all. (*c*) The **external fossa** is outside the deep epigastric artery. It is the most distinct of the three, from the way in which the cord or round ligament passes down within a glove-like process of the transversalis fascia. This fossa corresponds to the internal ring.

Varieties of inguinal hernia according to the condition of the vaginal process of peritoneum.—Inguinal herniæ have above been classified according to their relation to the deep epigastric artery. It remains to allude to the arrangement of these same herniæ according to the varying condition of the **processus funiculo-vaginalis.** This pouch of peritoneum, which paves the way for the passage of the testis before this organ makes its start, eventually becomes the tunica vaginalis below, in this fashion: Very soon after birth the process becomes obliterated at two spots—one near the internal ring, and one just above the testicle. The obliterative process, commencing first above and descending, and then, ascending from below, the shrivelling continues until nothing is left save the tunica vaginalis below. The following are possible outcomes from an imperfect obliteration of the process—the first, alone, is common:—

(1) If the process does not close at all, a descending **hernia** is called **congenital.** This may make its way into the scrotum. The testis is now enveloped and concealed by the hernia.

(2) If the process is closed only above, i.e. near the internal ring, the hernia may make its way behind the unobliterated processus funiculo-vaginalis. To this variety of inguinal **hernia** the name **infantile** has been given. Its only importance is that during any operation for such a hernia three layers of peritoneum would have to be divided before the hernial contents could be reached. If, again, during some exertion, the hernia rupture the obliterating septum which has formed above, the condition of things to be dealt with is practically that of a congenital hernia.

(3) If the processus funiculo-vaginalis be closed below and not above, a patent tubular process of peritoneum will lead down as far as the top of the testis. Any hernia into this process is called a **hernia into the funicular process.**

Inguinal hernia in the female.—The inguinal canal in women is smaller and narrower than in men. Inguinal hernia is, therefore, uncommon in the female sex, and only occurs before adolescence, in patients who happen to be the subjects of an unobliterated processus funiculo-vaginalis, which extends for a varying distance along the round ligament, and is called the canal of Nuck. Inguinal hernia in the female is, therefore, always congenital. It is, practically, always of the oblique variety, and travels along the round ligament towards the labium majus. Its coverings will be the same as those of the oblique variety in the male, save that the cremaster, as a distinct muscle, is absent, and any fibres of the internal oblique which may be present are but little developed.

Causes of hernia.—It will be well, while the anatomy of hernia is being considered, to refer briefly to the causes, as many of these are intimately bound up with the anatomy of the parts. Amongst the chief are the following:—

(1) **Hereditary,** viz. weakness of abdominal wall; openness of rings.

(2) **Weak spots.**—(*a*) The presence of the cord; (*b*) deficiency of some of the

layers below; (*c*) persistence of the original process of peritoneum; (*d*) a long mesentery or suspensory ligament of the intestines. Mr. Lockwood has shown that the mesentery is relatively larger in infancy, and that there is a rapid decrease after the second year. In adults its length is about eight inches, and any lengthening of the mesentery beyond this point is likely to be combined with a protuberant belly. He shows further, with regard to the range of descent or the excursus of the intestines, that it is extremely rare to find a mesentery so short, or attached so high, as to prevent the intestines escaping or being drawn from the abdomen.

The long mesentery of infancy and childhood is usually associated with considerable downward descent of the intestine; and in the adult it is quite common to find that the small intestines will pass an inch and a half beyond the right crural arch, one inch beyond the pubes, and up to the left crural arch.

(3) Stretching of the abdominal walls by pregnancies, etc.

(4) Increase of the volume and weight of the parts within: e.g. omentum by deposit of fat in it.

(5) Sex. Thus, men have larger inguinal rings. Women have a larger femoral arch, and one less well filled in by muscles, and with less strong fasciæ meeting, e.g. iliac and transversalis.

(6) Cough, asthma, bronchitis, habitual fretfulness or crying.

(7) Straining to expel urine, as with phimosis, stricture, stone in bladder, etc.

(8) Straining in defecation.

(9) Lifting heavy weights.

(10) Results of wounds or abscesses which have weakened the abdominal wall.

(11) Whatever diminishes the abdominal cavity, e.g. tight lacing.

FEMORAL HERNIA

As many of the parts concerned here are also met with in inguinal hernia, one description, given now, will suffice.

With regard to descriptions of the inguinal and femoral regions, it is always well to bear in mind the following:—(1) That the so-called rings and canals are merely weak spots in the inguinal and femoral regions, and that they do not exist distinctly, and do not get beyond the potential stage, unless made by a scalpel or a hernia; (2) that at the fold of the groin most of the layers blend together, and that descriptions of them as separate layers, for convenience sake in learning them, are more or less artificial; (3) that the description of these layers has been most needlessly complicated by the number of terms used, many of which are simply substitutes for others; (4) many of these terms are not only useless but incorrect, e.g. saphenous, crural, etc.

Parts concerned in femoral hernia. (1) **Skin and superficial fascia of groin.**—The latter consists of two layers: (*a*) **Superficial layer of superficial fascia.**—Fatty, met with over the whole groin, and continuous with the superficial fascia of the rest of the body. (*b*) **Deep layer of superficial fascia.**—Thin and membranous, only met with over the lower third of the abdominal wall and to the inner side of the groin. It is continuous through the scrotum with the deep layer of the superficial fascia of the perinaeum. Just below Poupart's ligament it is joined to the fascia lata. From these two facts it results that in rupture or giving way of the urethra the extravasated urine may come forwards by way of the genitals (page 1124) and from the continuity of the fascia make its way on to the abdomen, but not down on to the thigh.

Between the two layers of superficial fascia lie the superficial glands of the groin, the superficial branches of the common femoral artery, one or two cutaneous nerves, and some veins descending to the saphenous opening to join the long saphena vein.

(2) **Poupart's ligament.**—This is also known as the crural arch, a misnomer, as 'crus' means leg. A description of its shape and attachments is given on page 1114. Owing to the connection of the fascia lata to its lower border, the 'saphenous opening,' which is situated in the fascia lata, and has its upper cornu

blending with Poupart's ligament, will be affected by movements of the thigh, much as is the external abdominal ring, being tightened and stretched when the limb is extended and abducted, relaxed when it is adducted and flexed.

The **parts beneath the ligament** which block up the gap between it and the innominate bone are of the utmost importance in preventing the escape of a femoral hernia.

The different structures are arranged in three compartments, named from without inwards—A. **Outer,** or **iliac**; B. **Central,** or **vascular**; and C. **Inner,** or **pectineal.** Of these, the first is the largest; the second or central one lies on a plane slightly more superficial, or nearer to Poupart's ligament, than the other two; while the innermost compartment differs from the other two by not communicating with the pelvis, being closed above by fascia (*vide infra*). (A) The **outer,** or **iliac, compartment** is bounded in front by Poupart's ligament and the iliac fascia, which is here blending with it, behind by the ilium, externally by this bone and the sartorius, and internally by the ilio-pectineal septum, which, descending from the blending of the iliac fascia and Poupart's ligament above, passes down to the ilio-pectineal eminence, and thence to the inner aspect of the front of the capsule of the hip-joint. This compartment transmits the ilio-psoas and anterior crural and external cutaneous nerves. (B) The **central,** or **vascular, compartment** is bounded, in front, by Poupart's ligament and the transversalis fascia, which here blends with it, forming the so-called deep crural arch, and at the same time descends on to the front of the femoral sheath. The posterior boundary is formed by the meeting of the ilio-pectineal septum externally and the pectineal fascia or sheath from within—internally Gimbernat's ligament, and externally the ilio-pectineal septum. This central compartment transmits the external iliac vessels and crural branch of the genito-crural nerve. This lies to the outer side of the artery, the vein internally. Between the vein and the base of Gimbernat's ligament is the femoral canal (*vide infra*). (C) The **innermost,** or **pectineal, compartment** is bounded by the pectineal fascia continuous with the pubic part of the fascia lata, and behind by the pubic ramus. It lodges the upper end of the pectineus muscle, and the handle of a scalpel passed upwards along the muscle would be prevented from passing into the pelvis by Gimbernat's ligament and the blending of the pectineal fascia with the upper border of the pubic ramus.

(3) **Gimbernat's ligament.**—This is merely the triangular internal attachment of Poupart's ligament. Its apex is attached to the pubic spine; of its three borders, the base is free towards the vein and the femoral canal. Its upper border is continuous with Poupart's ligament, its lower is attached to the ilio-pectineal line.

(4) **Fascia lata.**—Two portions are described over the upper part of the thigh:—(*a*) An **iliac,** external and stronger, attached to Poupart's ligament in its whole extent and lying over the sartorius, ilio-psoas, and rectus. (*b*) A **pubic,** internal, weaker, and much less well defined, is attached above to the ilio-pectineal line and the spine of the pubes. The upper cornu of the 'saphenous opening' is at Gimbernat's ligament, and at the lower cornu the two portions of the fascia blend.

Their relation to the femoral vessels.—The iliac portion, being attached along Poupart's ligament, passes over these. The pubic portion, fastened down over the pectineus, which slopes down on to a deeper plane than the adjacent muscles, passes behind the femoral vessels to end on the capsule of the hip-joint.

(5) **Saphenous opening.**—This is doubly a misnomer. It is not an opening, but an oval depression, situated at the spot where the two parts of the fascia lata diverge on different levels. As without dissection it is not an opening, but an oval depression, fossa ovalis would have been a better term, were it not otherwise employed. Though the fascia lata is wanting here, there is no real opening, as the deficiency is made up by the deep layer of superficial fascia, or cribriform fascia, which fills up the opening. The term 'saphenous' is also misapplied: etymologically, it means 'very evident.' Now, it is notorious that in very many subjects this opening only becomes plain when rendered an artificial one by dissection; and that thus, with the limited opportunities of one or two subjects, it is by no means easy to verify the details about it which have been described as constant.

Uses of the 'saphenous opening.'—Though a weak spot, it is so on purpose to transmit the saphena to the femoral vein, and the superficial to the deep lymphatics. The depression is present in order to allow the saphena vein to be protected from pressure in flexion of the thigh.

Site.—At the inner and upper part of the thigh, with its centre an inch and a half below and outside the spine of the pubes.

Diameters.—One inch (25 mm.) vertically, by a half or three-quarters of an inch. *Shape:* oval, with its long axis downwards and outwards. *Two extremities* or *cornua:* upper blending with Gimbernat's ligament; lower, where the two parts of the fascia lata meet. *Two borders:* outer also known as the ligament of Hey, or femoral ligament, or falciform process of Burns. Semilunar in shape, arching downwards and outwards from Gimbernat's ligament to the inferior cornu. This lies over the femoral vessels, and is adherent to them; to it is fixed superficially the cribriform fascia (*vide infra*). The inner border is much less prominent, owing to the weakness of the pubic part of the fascia lata which forms it.

(6) **Femoral sheath.**—This is a funnel-shaped sheath, carried out by the femoral vessels under Poupart's ligament, and continuous above (in front) with the transversalis fascia as it descends to the ligament, lining the inner surface of the abdominal wall, and (behind) with the iliac fascia, and below continuous with the proper sheath of the femoral vessels.

It is not only funnel-shaped, but large and loose, for two reasons: (*a*) That there be plenty of room for the femoral vein, and the slowly moving venous current in it to ascend without compression; (*b*) to allow of all the movements of the thigh taking place—flexion and extension—without undue stretching of the vessels. By two connective tissue septa the sheath is divided into three compartments—the outer for the artery, the middle for the vein, and the internal one for the femoral canal (*vide infra*). Thus one septum lies between the artery and vein, and another between the vein and the femoral canal.

(7) **Femoral canal.**—Definition: the innermost division of the femoral sheath. The fascia transversalis and fascia iliaca meet directly on the outer side of the femoral artery, but not so closely on the inner side of the femoral vein. Hence a space exists here, perhaps to prevent the thin-walled vein, with its sluggish current, being pressed upon. Thus, a slight gap exists here—not a canal, unless so made by a knife or by the dilating influence of a hernia. *Length:* about three-quarters of an inch (19 mm.). *Limits:* below, saphenous opening; above, femoral ring (*vide infra*).

Boundaries.—Externally, a septum between it and the vein; internally, base of Gimbernat's ligament and meeting of fascia iliaca and transversalis; behind, fascia iliaca; in front, fascia transversalis.

Contents.—Cellular tissue and fat, continuous with extra-peritoneal fatty layer. A lymphatic gland, which is inconstant. Lymphatics passing from superficial (groin) glands to those deep in the iliac fossa.

(8) **Femoral ring.**—This is mainly an artificial product. It is the upper or abdominal opening of the femoral canal. *Shape:* oval, with its long axis transverse. It is larger in women. *Boundaries:* internally, Gimbernat's ligament; externally, the femoral vein; in front, Poupart's ligament and the thickening of the transversalis fascia attached to it, and called 'the deep crural arch'; behind, the pectineus and the ilio-pectineal line. It is closed by the septum crurale, which is a barrier of fatty connective tissue, continuous with the extra-peritoneal fatty layer, perforated by lymphatics passing from the superficial to the deep group.

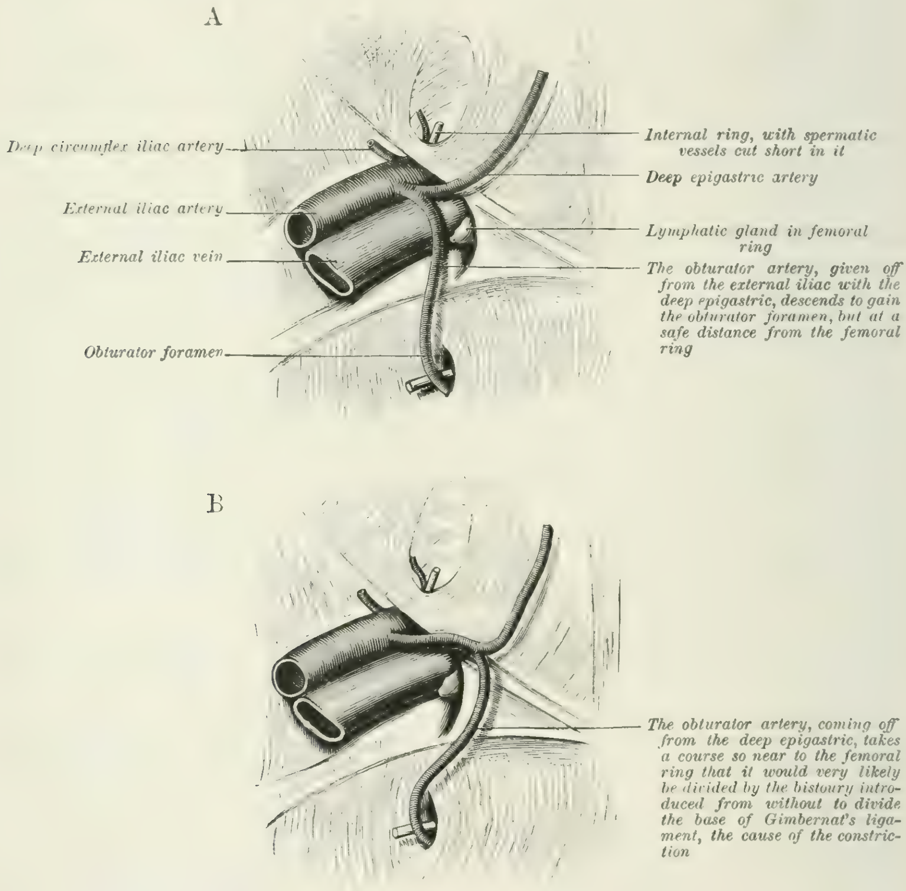
Position of vessels around the ring.—Outside, the femoral vein; above, the epigastric vessels; towards the inner side there may be an unimportant branch between the epigastric artery above and the obturator below.

If, instead of the above unimportant branch, the obturator artery comes off abnormally from the deep epigastric, it will descend, and usually does so, close to the junction of the external iliac and common femoral vein, and thus to the outer, and so the safe, side of the ring (fig. 704, A). In a very few cases it curves more inwards, close to Gimbernat's ligament, and thus to the inner side of the ring, and is then in great danger (fig. 704, B). Sir William Lawrence calculated that this took place once in a hundred cases.

Course of femoral hernia.—At first this is downwards in the femoral canal.

A pouch of peritoneum having been gradually, after repeated straining, coughing, etc., pushed through the weak spot, the femoral ring, further weakened perhaps, together with all the parts in the femoral arch, by child-bearing, some extra effort will force intestine or omentum into this pouch and thus form a hernia. Thus formed, femoral hernia passes at first downwards in the femoral canal as far as the saphenous opening, but, as a rule, does not go farther downwards on the thigh, but mounts forwards and upwards, and somewhat outwards, even reaching the level of Poupart's ligament. The reasons for this change of position are—(1) The narrowing of the femoral sheath, funnel-like, i.e. wide above but narrowed below; (2) the unyielding nature of the lower margin of the saphenous opening; (3) the fact that this margin and the outer border are united to the femoral sheath; (4) the constant flexion of the thigh; (5) the fact that vessels (chiefly veins) and lymphatics descend to the saphenous opening, the veins to join the saphena vein, and the lymphatics to join the deeper group: these descending vessels serve to loop upwards or suspend a femoral hernia, and thus prevent its further course downwards.

FIG. 704.—IRREGULARITIES OF THE OBTURATOR ARTERY. (After Gray.)


A
Deep circumflex iliac artery
External iliac artery
External iliac vein
Obturator foramen
Internal ring, with spermatic vessels cut short in it
Deep epigastric artery
Lymphatic gland in femoral ring
The obturator artery, given off from the external iliac with the deep epigastric, descends to gain the obturator foramen, but at a safe distance from the femoral ring
B
The obturator artery, coming off from the deep epigastric, takes a course so near to the femoral ring that it would very likely be divided by the bistoury introduced from without to divide the base of Gimbernat's ligament, the cause of the constriction

Coverings of a femoral hernia.—(A) **At the upper** or **femoral ring** it obtains peritoneum, extra-peritoneal fat, and septum crurale.

(B) **In the canal,** a coating of the femoral sheath.

(C) **At the external** or **superficial opening,** further coverings of cribriform fascia, skin, and superficial fascia are added.

Some of these may be deficient by the hernia bursting through them, or they may be matted together. Sir A. Cooper thought this especially likely to occur with the layer of femoral sheath and septum crurale to which he gave the name of *fascia propria.*

PARTS CONCERNED IN UMBILICAL HERNIA

A hernial protrusion at the umbilicus, or exomphalos, may occur at three distinct periods of life, according to the anatomy of the part. Any account of umbilical hernia would be incomplete without an attempt to explain how this region, originally a most distinct opening, is gradually closed and changed into a knotty mass of scar, the strongest point in the abdominal wall.

During the first weeks of fœtal life, in addition to the urachus, umbilical arteries, and vein, some of the membranes and a portion of the intestine pass through the opening to join that part of the digestive tract which is developed outside the abdomen up to a certain time, and then re-enters that cavity. Occasionally this condition persists, owing to failure of development, and the child is born with a large hernial swelling outside the abdomen, imperfectly covered with skin and peritoneum. To this condition the term **congenital umbilical hernia** should be applied.

Later on in fœtal life it is the umbilical vessels alone which pass through this opening. At birth there is a distinct ring, which can be felt for some time after in the flaccid walls of an infant's belly. If this condition persist, a piece of intestine may find its way through, forming the condition which should be known as **infantile umbilical hernia.**

This condition is not uncommon. Why it is not more frequently met with is explained by the way in which this ring of infancy is closed and gradually converted into the dense mass of scar tissue so familiar in adult life. This is brought about (1) by changes in the ring itself; (2) by changes in the vessels which pass through it.

(1) **Changes in the ring itself.**—The umbilical ring is surrounded by a sphincter-like arrangement of elastic fibres, best seen during the first few days of fœtal life, on the posterior wall of the belly. In older infants these fibres lose their elasticity, become more tendinous, and then shrink more and more. As they contract they divide, as by a ligature, the vessels passing through the ring, thus accounting for the fact that the cord, wherever divided, drops off at the same spot and without bleeding.

(2) **Changes in the vessels themselves.**—When blood ceases to traverse these, their lumen contains clots, their muscular tissue wastes, while the connective tissue of their outer coat hypertrophies and thickens. Thus, the umbilical vessels and the umbilical ring are, alike, converted into scar-tissue, which blends together. This remains weak for some time, and may be distended by a hernia (infantile).

Finally, we have to consider the state of the umbilicus in adult life. The very dense, unyielding, fibrous knot shows two sets of fibres:—(1) Those decussating in the middle line; and (2) two sets of circular fibrous bundles which interlace at the lateral boundaries of the ring. The lower part of the ring is stronger than the upper. In other words, **umbilical hernia of adult life,** when it comes through the ring itself and not at the side, always comes through the upper part. In the lower three-fourths of the umbilicus the umbilical arteries and urachus are firmly closed by matting in a firm knot of scar-tissue; in the upper there is only the umbilical vein and weaker scar. To the lower part run up the umbilical arteries and the urachus. Owing to the rapid growth of the abdominal wall and pelvis before puberty, and the fact that the urachus and the umbilical arteries, being of scar-tissue, elongate with difficulty, the latter parts depress the umbilicus by reason of their intimate connection with its lower half.

Coverings of an umbilical hernia.—These, more or less matted together, are: —(1) Skin; (2) superficial fascia, which loses its fat over the hernia; (3) prolongation of scar-tissue of the umbilicus gradually stretched out; (4) transversalis fascia;

(5) extra-peritoneal fatty tissue; (6) peritoneum. If the hernia come through above the umbilicus, or just to one side, the coverings will be much the same; but, instead of the layer from the umbilical scar, there will be one from the linea alba.

THE BACK

Median furrow.—This is more or less marked according to the muscular development, lying between the trapezii and complexi, in the cervical region, and the erectores spinæ lower down. The lower end of the furrow corresponds to the interval between the spines of the last lumbar and the first sacral vertebræ (Holden).

Vertebral spines.—Those of the upper cervical region are scarcely to be made out even by deep pressure. That of the axis may be detected in a thin subject. Over the spines of the middle three cervical vertebræ is normally a hollow, owing to these spines receding from the surface to allow of free extension of the neck. The seventh cervical is prominent, as its name denotes. Between the skull and atlas, or between the atlas and axis, a sharp-pointed instrument might penetrate, especially in flexion of the neck.

Of the **thoracic spines**, the first is the most prominent; the third should be noted as on a level with the inner end of the scapular spine, and in some cases with the bifurcation of the trachea; that of the seventh with the lower angle of the scapula; that of the twelfth with the lowest part of the trapezius and the head of the twelfth rib. The obliquity and overlapping of the thoracic spines is to be remembered.

Of the **lumbar spines**, the most important are the second, which corresponds to the termination of the cord, and that of the fourth, which marks the highest part of the iliac crests and the bifurcation of the abdominal aorta. The lumbar spines project horizontally, and correspond with the vertebral bodies. The third is a little above the umbilicus.

Owing to the obliquity of the thoracic spines, most of them do not tally with the heads of the corresponding ribs. Thus, the spine of the second corresponds with the head of the third rib; the spine of the third with the head of the fourth rib; and so on till we come to the eleventh and twelfth vertebræ, which do tally with their corresponding ribs (Holden).

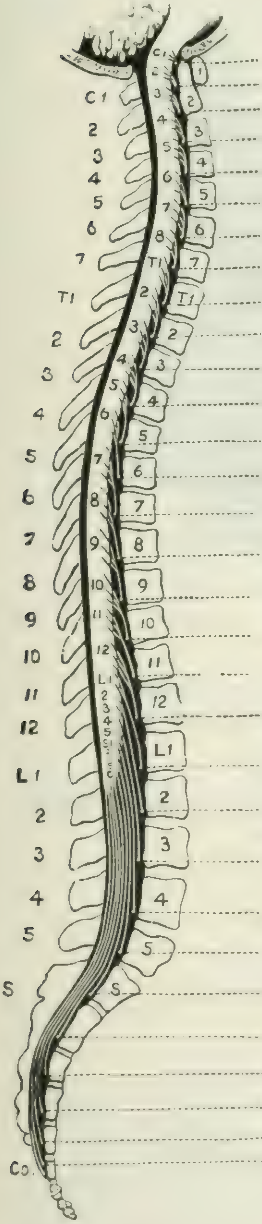
The lower ribs may be felt outside the erector spinæ, but, in counting them from below, it must be remembered, as pointed out by Holl, that in quite a considerable percentage the last rib is so abnormally short that it does not reach as far as the outer border of the sacro-lumbalis; or so rudimentary as to more resemble a transverse process. In these cases the lower end of the pleura may pass from the lower part of the twelfth thoracic vertebra, almost horizontally to the lower edge of the eleventh rib.

Muscles.—The student will remember the great number and complexity and the numerous tendons of the muscles which run up on either side of the spine; the firmness and inextensibility of their sheaths; the large amount of cellular tissue between them; and the fact that towards the nape of the neck these muscles lie exposed instead of being protected in gutters, as is the case below: all these anatomical points explain the extreme painfulness and obstinacy of sprains here.

Trapezius.—To map out this muscle, the arm should be raised to a right angle with the spine. The external occipital protuberance should be dotted in, and the superior nuchal line passing out from this; below, the twelfth thoracic spine should be marked; and externally, the outer third of the clavicle and the commencement of the scapular spine. Then a line should be drawn from the protuberance vertically downwards to the twelfth thoracic spine; a second from about the middle of the superior nuchal line to the posterior and outer third of the clavicle; and a third from the last thoracic spine upwards and outwards to the spine of the scapula.

Latissimus dorsi.—The arm being raised above a right angle, the spines of the sixth thoracic and the third sacral vertebræ should be marked; then the outer lip of the crest of the ilium, the lower two or three ribs, the lower angle of the scapula, and the posterior fold of the axilla, and finally the bicipital groove should all be marked.

FIG. 705.—DIAGRAM AND TABLE SHOWING THE APPROXIMATE RELATION TO THE SPINAL NERVES OF THE VARIOUS MOTOR, SENSORY, AND REFLEX FUNCTIONS OF THE SPINAL CORD. (Arranged by Dr. Gowers from anatomical and pathological data.)



	MOTOR	SENSORY	REFLEX
I C			
2			
3	Sterno-mastoid Trapezius	Neck and scalp	
4		Neck and shoulder	
5	Diaphragm		
6	Serratus Shoulder	Shoulder	
7	Arm musc.	Arm	Scapular
8	Hand (ulnar lowest)	Hand	
I T			
2			
3			
4			
5		Front of thorax	
6	Intercostal muscles		Epigastric
7		Ensiform area	
8			
9			
10	Abdominal muscles		
11		Abdomen (Umbilicus 10th)	Abdominal
12		Buttock, upper part	
I L			
2	Flexors, hip	Groin and scrotum (front) outer side	Cremasteric
3	Extensors, knee Adductors	Thigh front	Knee-joint
4	hip	inner side Leg, inner side	
5	Abductors	Buttock, lower part	Gluteal
I S	Extensors(?) Flexors, knee (?)	Back of thigh	Foot clonus
2	Muscles of leg moving foot	Leg and foot except inner part	Plantar
3	Perinæal and anal muscles	Perinæum and anus	
4			
5			
Co.		Skin from coccyx to anus	

FIG. 706.—CHIEF ARTERIAL ANASTOMOSES ON THE SCAPULA.
(From a dissection in the Hunterian Museum.)

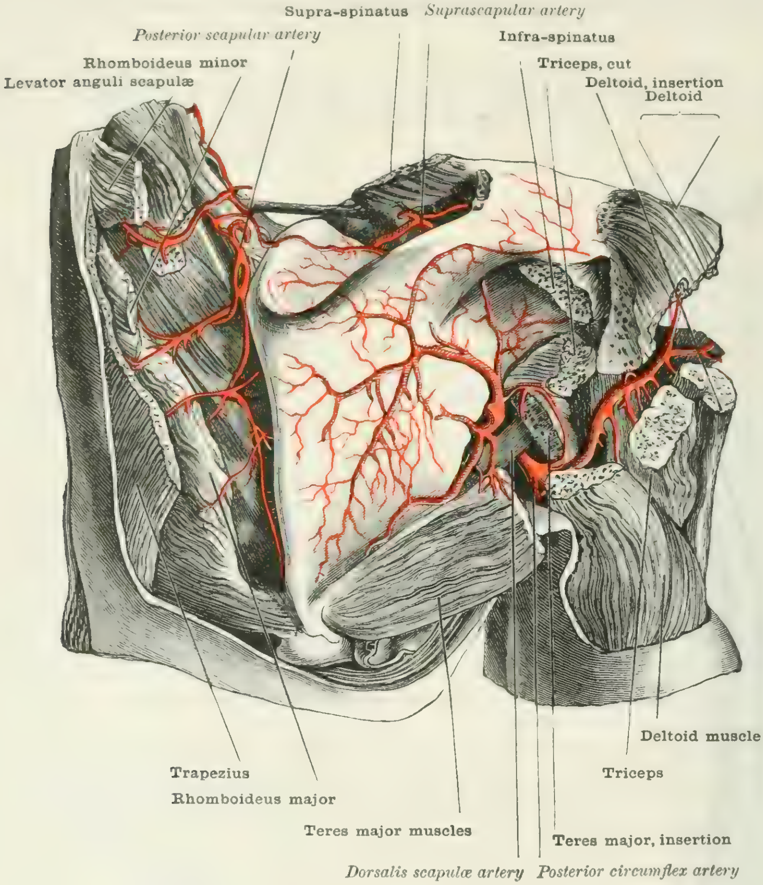
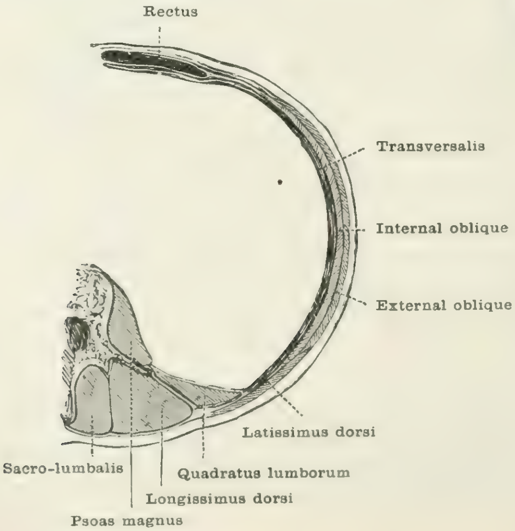
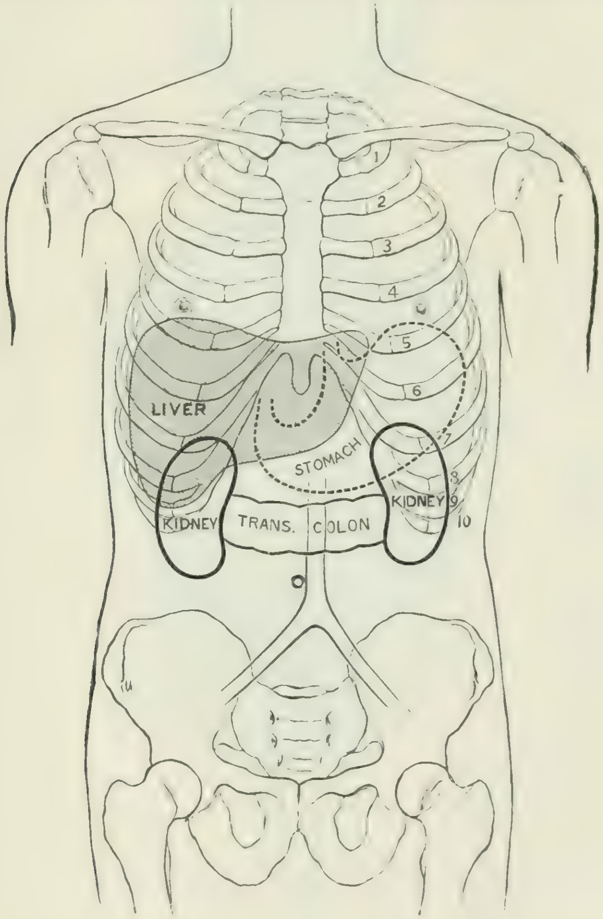

Supra-spinatus
Suprascapular artery
Posterior scapular artery
Infra-spinatus
Rhomboideus minor
Triceps, cut
Levator anguli scapulæ
Deltoid, insertion
Deltoid
Deltoid muscle
Trapezius
Triceps
Rhomboideus major
Teres major muscles
Teres major, insertion
Dorsalis scapulæ artery
Posterior circumflex artery

FIG. 707.—ARRANGEMENT OF LUMBAR APONEUROSIS AT LEVEL OF THIRD LUMBAR VERTEBRA.


Rectus
Transversalis
Internal oblique
External oblique
Latissimus dorsi
Sacro-lumbalis
Quadratus lumborum
Longissimus dorsi
Psoas magnus

A vertical line from the sixth thoracic to the third sacral spine will give the spinal origin of the muscle. Another from the third sacral spine to a point on the iliac crest, an inch or more outside the edge of the erector spinæ, will give the origin of the muscle from the sheath of the erector spinæ and the ilium. A line from the sixth thoracic spine, almost transversely at first, with increasing slight obliquity over the inferior angle of the scapula to the axilla and bicipital groove, will mark the upper border of the muscle. Another very oblique line from the point on the iliac crest upwards and outwards to the axilla will give the lower border and the tapering triangular apex of the insertion. The muscle may be attached to the angle of the scapula, or separated from it by a bursa.

FIG. 708.—RELATIONS OF THE ABDOMINAL VISCERA TO THE ANTERIOR PARIETES. (Treves.)



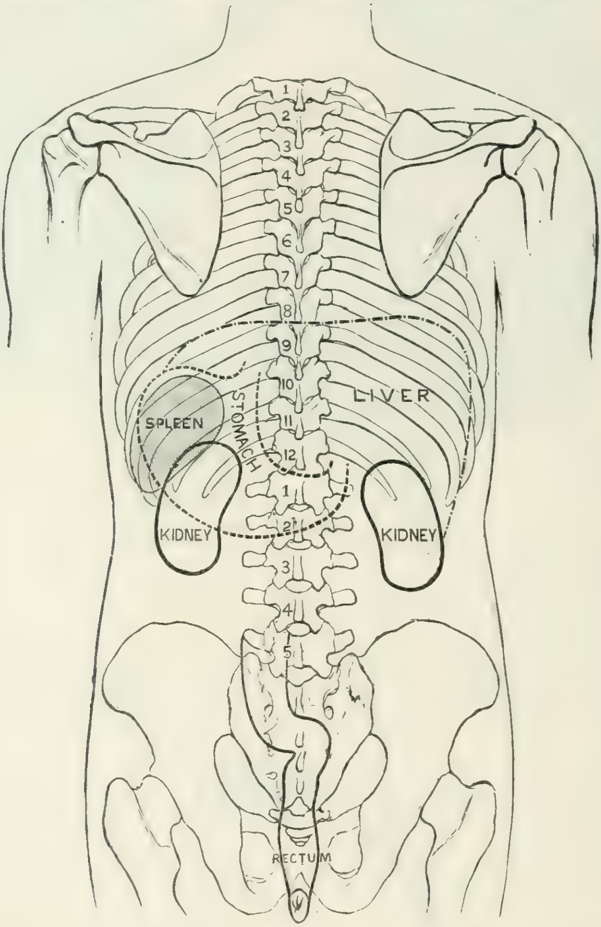
Triangle of Petit.—This small space lies above the crest of the ilium, at about its centre, bounded by the anterior edge of the latissimus and the posterior border of the external oblique.

Origin of spinal nerves.—It is very important to remember the relations of these to the vertebral spines, in determining the results of disease or injury of the cord and the parts thereby affected. The above relation may be given briefly as follows:—

The origins of the eight cervical nerves correspond to the cord between the occiput and the sixth cervical spine. The upper six thoracic come off between the above spine and that of the fourth thoracic vertebra. The origins of the lower six thoracic nerves correspond to the interval between the fourth and the tenth thoracic spines. The five lumbar arise opposite the eleventh and twelfth thoracic spines; and the origins of the five sacral correspond to the first lumbar spines. The diagram and table (fig. 705), arranged by Dr. Gowers from anatomical and pathological data, show the relations of the origins of the nerves to their exits from the vertebral canal, and the regions supplied by each.

Scapula, its muscles and arterial anastomoses.—Amongst the landmarks in the back, the student should be careful to trace the angles and borders of the scapula as far as these are accessible. The upper border is the one most thickly covered. With the hands hanging down, the upper angle corresponds to the upper border of the second rib; the lower angle to the seventh intercostal space; and the root of the spine of the scapula to the interval between the third and fourth thoracic spines. Fig. 706 shows the chief arteries around the scapula. The anastomoses on the acromial process between the suprascapular, acromio-thoracic, and circumflex arteries are not shown.

FIG. 709.—RELATIONS OF THE ABDOMINAL VISCERA TO THE POSTERIOR PARIETES. (Treves.)

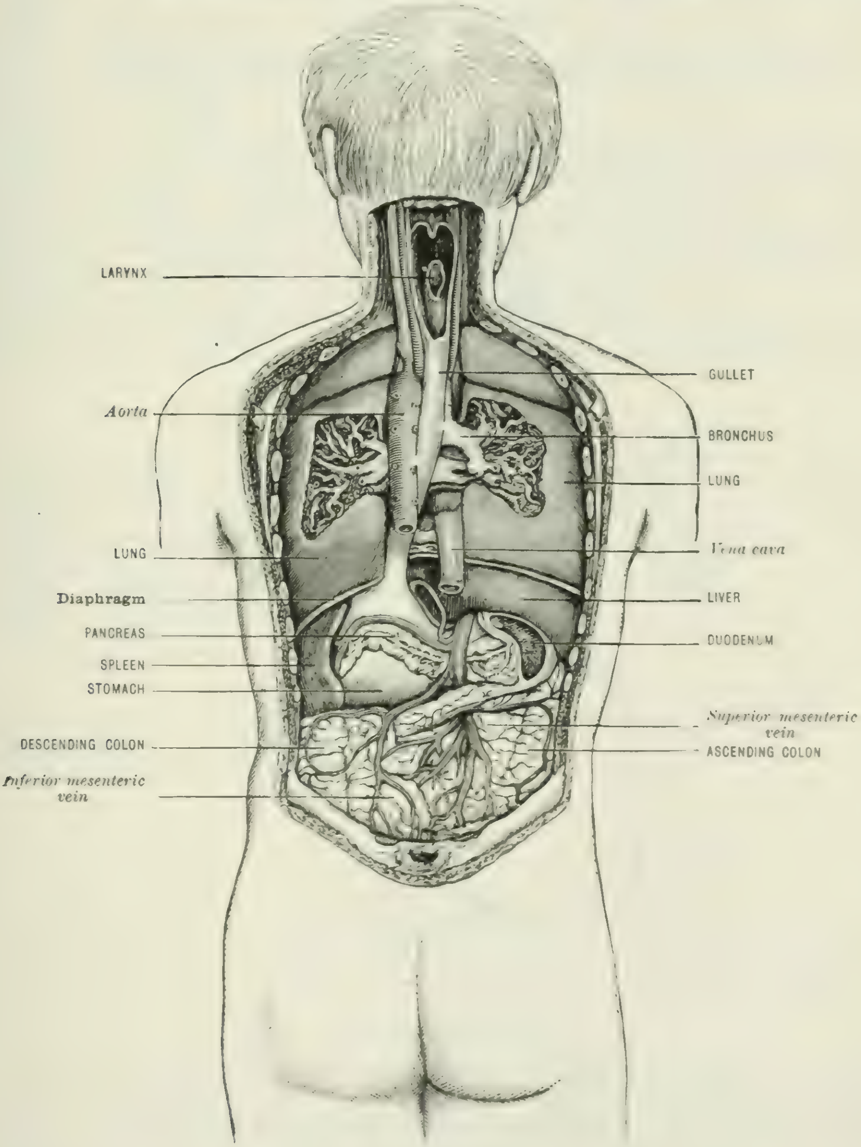


Lumbar fascia.—In the loins, the muscles which fill in the space between the last rib and the crest of the ilium should be carefully noted, owing to the frequency of operations here. When the latissimus dorsi, the oblique, the transversalis, the erector spinæ, and quadratus have been described, the lumbar fascia (the posterior aponeurosis of the transversalis), and the three layers into which it divides posteriorly (fig. 707) should be remembered.

Viscera.—Several of these, which can be mapped in behind—viz. the kidneys, spleen, etc.—have been already mentioned (pages 1119, 1120). See also page 1119 for the incision for lumbar colotomy.

The commencement of the **trachea** and **œsophagus** has been given in front as corresponding to the fifth cervical vertebra. If examined from behind, this point, owing to the obliquity of the spines, would be a little lower down. The **trachea,** about five inches long, descending in the middle line, bifurcates opposite to the interval between the third and fourth thoracic spines. The **bronchi** enter the lungs at about the level of the fifth thoracic spine, the right being the shorter, wider, and more horizontal. The **œsophagus,** about ten inches in length, starting in the middle line, curves, at once gradually to the left, and to the root of the neck; from this point it tends to regain the middle line up to the fifth thoracic vertebra; thence finally turns again, and more markedly to the left, and passes

FIG. 710.—ABDOMINAL VISCERA, FROM BEHIND. (Rüdinger.)

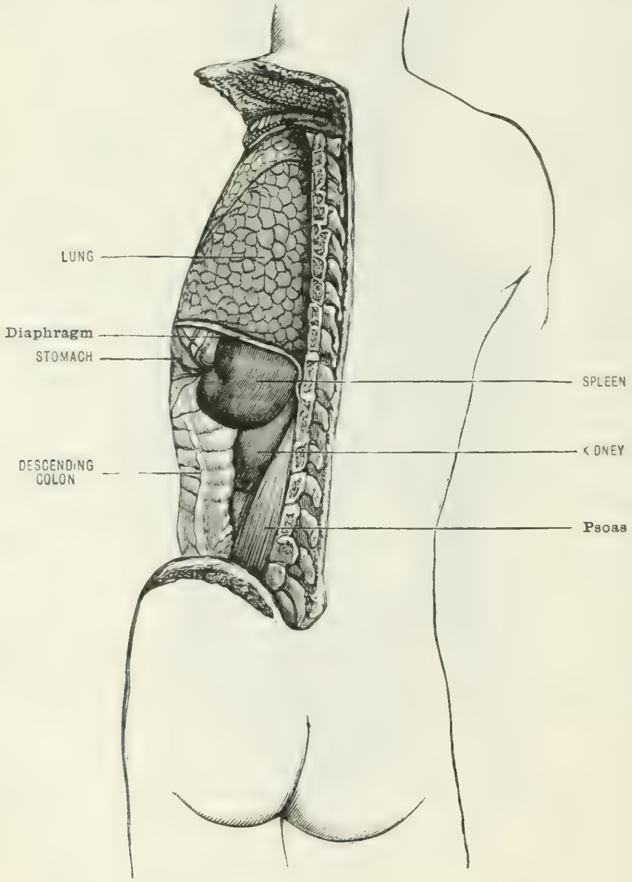

LARYNX
Aorta
LUNG
Diaphragm
PANCREAS
SPLEEN
STOMACH
DESCENDING COLON
Inferior mesenteric vein
GULLET
BRONCHUS
LUNG
Vena cava
LIVER
DUODENUM
Superior mesenteric vein
ASCENDING COLON

through the diaphragm opposite to the tenth or eleventh thoracic vertebra, or the ninth or tenth thoracic spine.

The **aorta** reaches the left side of the vertebral column, with its arch just above the fourth thoracic spine, and thence descends on the front of the column, with a slight tendency to the left, to bifurcate opposite the fourth lumbar spine.

The following table, from Holden and Windle, with additions, will be found very useful in determining the relation of numerous viscera and other structures to the bodies of the vertebræ.

FIG. 711.—VIEW OF THE SPLEEN, ETC., FROM BEHIND. (Rüdinger.)



Cervical

First. Level of hard palate.

Second. Level of free edge of upper teeth.

Second and third. Superior cervical ganglion of sympathetic.

Fourth. Hyoid bone. Upper aperture of larynx.

Fifth. Middle cervical ganglion, thyroid cartilage, and rima glottidis. Between this and the last would be the bifurcation of the common carotid.

Sixth. Cricoid cartilage. Ending of pharynx and larynx.

Seventh. Inferior cervical ganglion. Apex of lung, higher in the female than in the male. Arch of thoracic duct.

Thoracic

First. Summit of arch of subclavian (Godlee).

Second. Level of episternal notch. This is usually opposite the fibro-cartilage between the second and third. Bifurcation of innominate (Godlee).

Third. Level of junction between the manubrium and the gladiolus. This is sometimes opposite the fifth. Lowest limit of superior mediastinum. Bifurcation of trachea. Beginning of superior cava. Highest part of aortic arch.

Fourth. Second piece of aortic arch reaches spine. Arch of vena azygos major.

Fifth. Termination of third piece of aortic arch.

Fifth to eighth. Base of heart.

Sixth. Pulmonary and aortic valves. Commencement of aorta and pulmonary artery. End of superior cava.

Seventh. Mitral orifice.

Eighth. Tricuspid orifice.

Ninth. Lower level of manubrium. Openings in diaphragm for inferior vena cava and œsophagus. Upper limit of spleen.

Tenth. Level of tip of xiphoid cartilage. Lower limit of lung posteriorly. Upper limit of liver comes to the surface posteriorly. Œsophagus passes through diaphragm. Cardiac orifice of stomach.

Eleventh. Lower border of spleen. Suprarenal capsule.

Twelfth. Lowest part of pleura. Aorta passes through diaphragm (upper border). Cœliac axis (lower border). Pylorus. Upper border of kidney.

Lumbar

First. Pancreas. Pelvis of kidney. Renal arteries (ending).

Second. Spinal cord ends at junction of first and second. Third piece of duodenum. Receptaculum chyli. Lower end of left kidney.

Third. Umbilicus, opposite fibro-cartilage, between this and fourth. Lower end of right kidney. Lower limit of liver on right side.

Fourth. Bifurcation of aortic arch. Highest part of iliac crest.

Fifth. Commencement of superior vena cava.

Sacral

Third. End of first piece of rectum. Lower limit of spinal membranes.

Coccyx (tip). End of second piece of rectum.

SUPERFICIAL ANATOMY OF THE UPPER LIMB

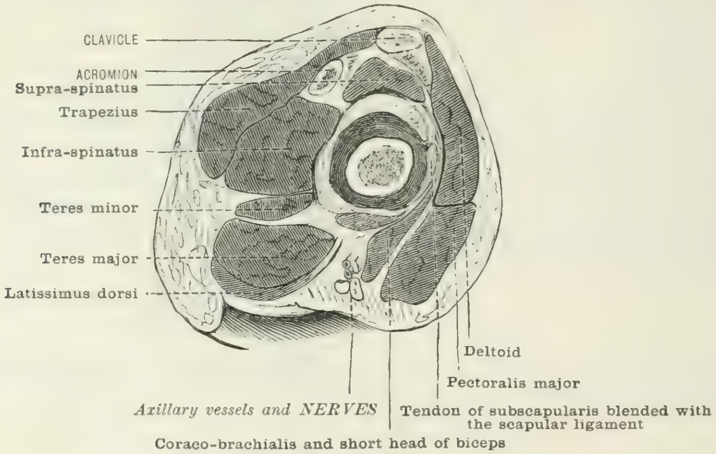
THE SHOULDER

The following **surface-marks**, of the greatest importance in determining the nature of shoulder injuries, can be made out here :—The **clavicle** in its whole extent, the **acromion process**, the **great tuberosity**, and **upper part of the shaft of the humerus**. Much less distinctly, the position of the **coracoid process** and the **head of the humerus** can be made out. The anterior margin of the **clavicle**, convex internally and concave externally, can be made out in its whole extent, the bone, if traced outwards, being found not to be horizontal, but rising somewhat to its junction with the acromion. The tip of this process, when the arm hangs by the side, is in the same line as the external condyle and the styloid process of the radius. On the inner side, the head and internal condyle of the humerus and the styloid process of the ulna are in the same line. Thus the great tuberosity looks outwards, the head inwards, and the lesser tuberosity somewhat forwards. Between the two tuberosities runs the **bicipital groove**, which, with the arm in the above position, looks directly forwards. In thin subjects its lower part can be defined. Besides the tendon and its synovial sheath, the insertion of the latissimus dorsi, the humeral branch of the acromio-thoracic artery, and the anterior circumflex artery run in the groove. When the fingers are placed on the acromion, and the thumb in the axilla, the lower edge of the glenoid cavity can be felt; and if the humerus be rotated (the elbow-joint being flexed), the head of the humerus can be felt also.

The **characteristic roundness of the shoulder** is due to the deltoid, supported by the head of the humerus and the tuberosities (fig. 715). Close to the clavicle, between the contiguous origins of the pectoralis major and deltoid, is the infraclavicular fossa, in which lie the cephalic vein and the humeral branch of the acromio-thoracic artery. On pressing deeply here, the coracoid process can be made out if the muscles are relaxed and the axillary artery compressed against the second rib.

On raising the arm and abducting it, the different parts of the **deltoid** can often be made out—viz. fibres from the lower border of the spine of the scapula, the outer edge of the acromion, and the outer third or more of the front of the clavicle; the characteristic knitting of the surface owing to the presence of muscular bundles, separated by depressions caused by the tendinous septa, will also be seen. The muscle will be marked out by a base-line reaching along the above bony points, and two sides converging from its extremities to the apex, a point on the outer surface of the humerus, about its centre. To map out the **pectoralis major,** a line should be drawn down the lateral aspect of the sternum as far as the sixth costal cartilage, and then two others marking the borders of the muscle—the upper corresponding to the deltoid, the lower starting from the sixth cartilage, and the two converging to the folded tendon, which is inserted as a double layer into the outer bicipital ridge. The **pectoralis minor** will be marked out by two lines, from the upper border of the third and the lower border of the fifth rib, just external to their cartilages, and meeting at the coracoid process. The lower line gives the level of the long thoracic artery; the upper, where it meets the line of the axillary artery, that of the acromio-thoracic.

FIG. 712.—TRANSVERSE SECTION THROUGH THE RIGHT SHOULDER-JOINT, SHOWING THE STRUCTURES IN CONTACT WITH IT. (Braune.)

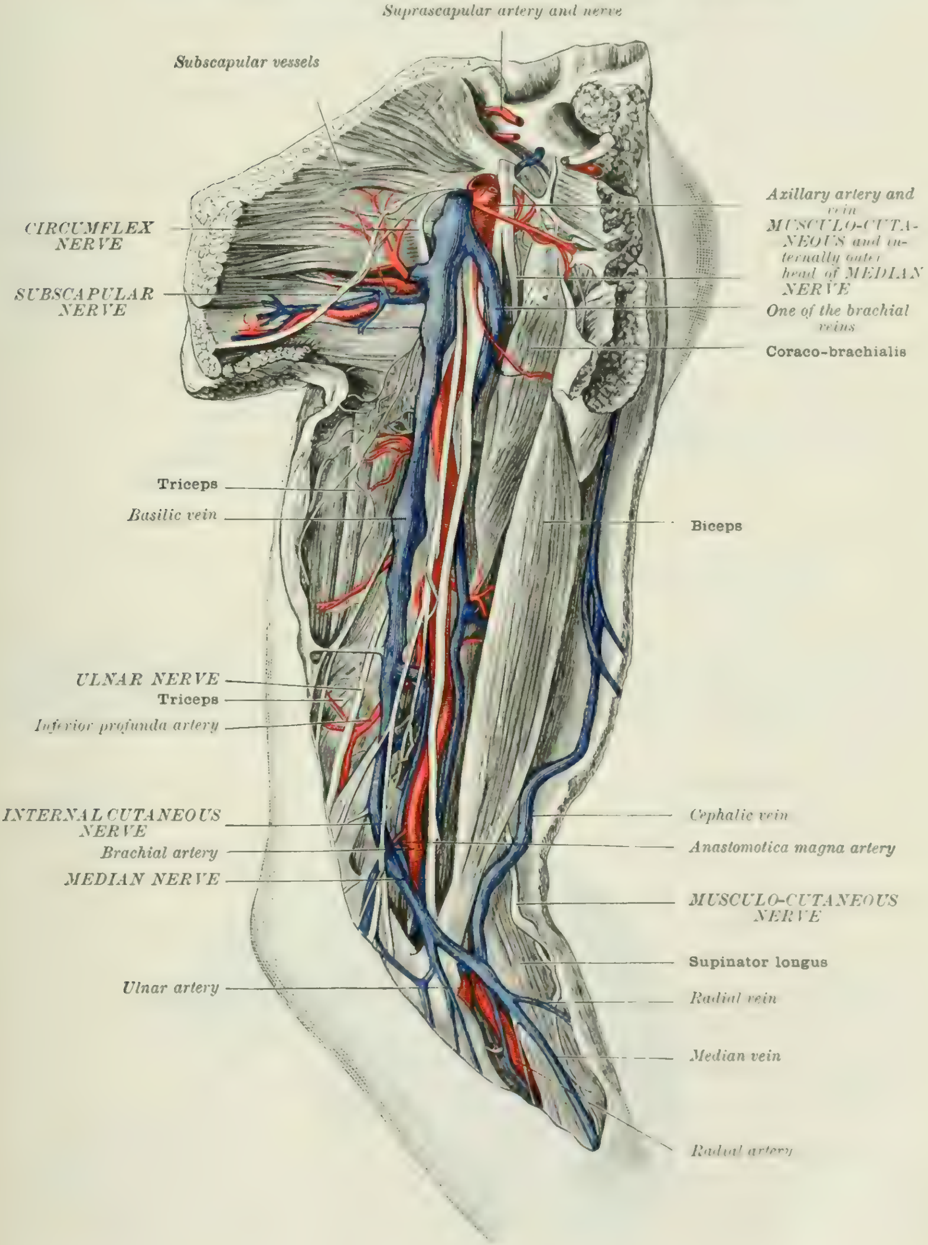

CLAVICLE
ACROMION
Supra-spinatus
Trapezius
Infra-spinatus
Teres minor
Teres major
Latissimus dorsi
Deltoid
Pectoralis major
Axillary vessels and NERVES
Tendon of subscapularis blended with the scapular ligament
Coraco-brachialis and short head of biceps

When the arm is abducted and the humerus rotated a little outwards, the prominence of a well-developed **coraco-brachialis** comes into view; a line drawn from the centre of the clavicle along the inner border of this muscle to its insertion into the humerus gives the line of the axillary artery.

The depression of the **axilla** is best marked when the arm is raised from the side to an angle of about 45°, and when the muscles bounding it in front and behind are contracted. In proportion as the arm is raised, the hollow becomes less, the head of the humerus now projecting into it. When the folds are relaxed by bringing the arm to the side, the fingers can be pushed into the space so as to examine it.

FIG. 713.—THE BRACHIAL ARTERY.

(From a dissection in the Museum of the Royal College of Surgeons.)


Suprascapular artery and nerve
Subscapular vessels
Axillary artery and vein
CIRCUMFLEX NERVE
MUSCULO-CUTANEOUS and internally outer head of MEDIAN NERVE
SUBSCAPULAR NERVE
One of the brachial veins
Coraco-brachialis
Triceps
Basilic vein
Biceps
ULNAR NERVE
Triceps
Inferior profunda artery
INTERNAL CUTANEOUS NERVE
Cephalic vein
Brachial artery
Anastomotica magna artery
MEDIAN NERVE
MUSCULO-CUTANEOUS NERVE
Supinator longus
Ulnar artery
Radial vein
Median vein
Radial artery

The circumflex nerve and posterior circumflex vessels wind round the humerus under the deltoid, a little above the centre of this muscle.

To trace the **synovial membrane of the shoulder-joint** is a comparatively simple matter (fig. 715). Covering both aspects of the free edge of the glenoid ligament, it lines the inner aspect of the capsule whereby it reaches the articular margin of the head of the humerus; there is a distinct reflection, below, from the capsule on to the humeral neck before the rim of the cartilage is reached. An extensive protrusion of synovial membrane takes place in the form of a synovial bursa, at the inner and anterior part of the capsule, near the root of the coracoid process under the tendon of the subscapularis. Another protrusion takes place between the two tuberosities along the bicipital groove, as low as the insertion of the pectoralis major. A third synovial protrusion may be seen, but not frequently, at the outer or posterior aspect, in the form of a bursa, under the infraspinatus

Fig. 714.—Section through the Middle of the Right Upper Arm. (Heath.)

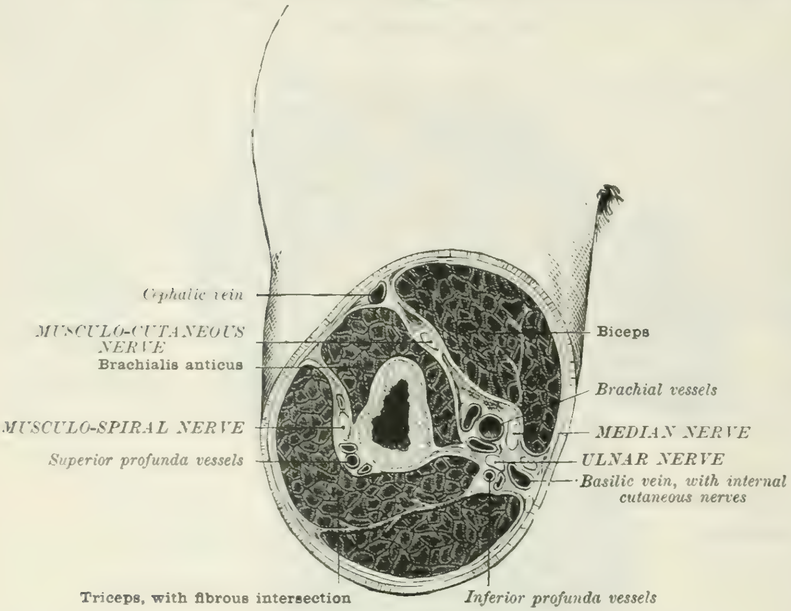
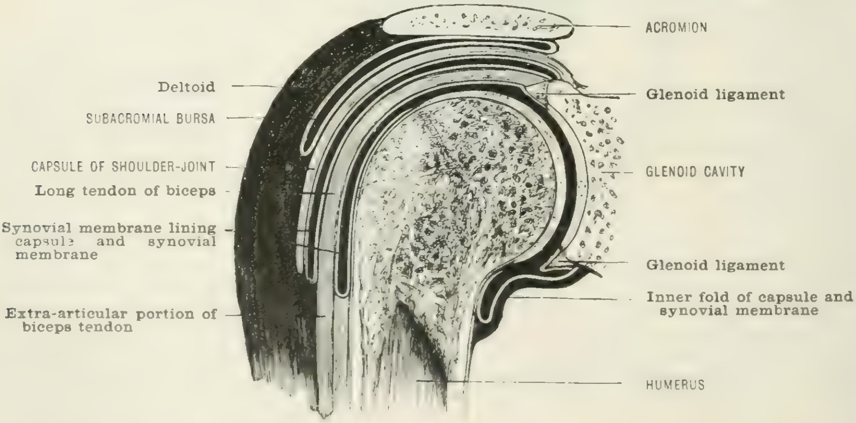

Cephalic vein
MUSCULO-CUTANEOUS NERVE
Brachialis anticus
MUSCULO-SPIRAL NERVE
Superior profunda vessels
Biceps
Brachial vessels
MEDIAN NERVE
ULNAR NERVE
Basilic vein, with internal cutaneous nerves
Triceps, with fibrous intersection
Inferior profunda vessels

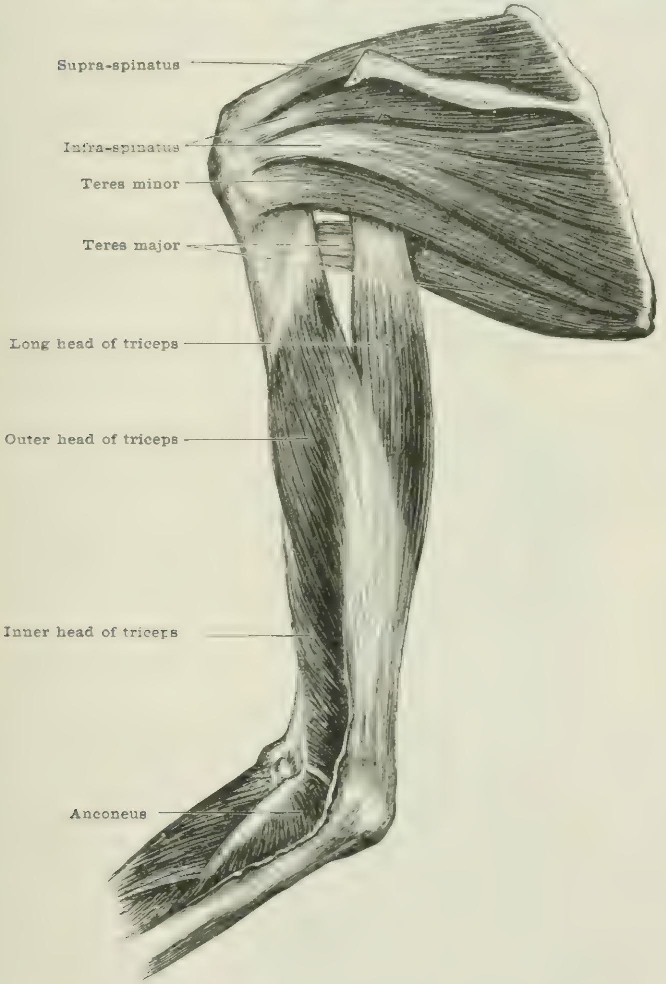
Fig. 715.—Diagrammatic Section of Shoulder through Bicipital Groove. (Anderson.)


ACROMION
Deltoid
Glenoid ligament
SUBACROMIAL BURSA
CAPSULE OF SHOULDER-JOINT
GLENOID CAVITY
Long tendon of biceps
Synovial membrane lining capsule and synovial membrane
Glenoid ligament
Inner fold of capsule and synovial membrane
Extra-articular portion of biceps tendon
HUMERUS

tendon. Thus the continuity of the capsule is interrupted by **two** and **sometimes three apertures.**

The **shaft of the humerus** is well covered by muscles in the greater part of its extent, especially above. Below the insertion of the deltoid, the outer border of the bone can be traced downwards into the external supracondyloid ridge. The inner border and ridge are less prominent. Attached to these ridges and borders are the intermuscular septa, each lying between the triceps and brachialis anticus, and the outer one giving origin to the brachio-radialis (supinator longus) and extensor carpi radialis longior as well. The outer septum is perforated by the superior profunda vessels and the musculo-spiral nerve, the inner by the inferior profunda and anastomotica magna arteries and the ulnar nerve. On either side of the well-known prominence of the **biceps** is a furrow. Along the outer ascends the cephalic vein. The inner corresponds to the line of the basilic vein which lies superficial to the deep fascia below the middle of the arm, and superficial and internal to the brachial vessels and median nerve.

FIG. 716.—BACK VIEW OF THE SCAPULAR MUSCLES AND TRICEPS.



A line drawn along the inner edge of the biceps from the insertion of the teres major to the middle of the bend of the elbow corresponds to the **brachial artery.** In the upper two-thirds, this artery can be compressed against the bone by pressure outwards; in its lower third the humerus is behind it, and pressure should be made backwards. The superior profunda comes off from the highest part of the artery and courses with the musculo-spiral nerve (fig. 714); the nutrient artery arises opposite the middle of the humerus; the inferior profunda below the middle, and courses with the ulnar nerve through the intermuscular septum to the back of the internal condyle. The anastomotica is given from one to two inches above the bend of the elbow.

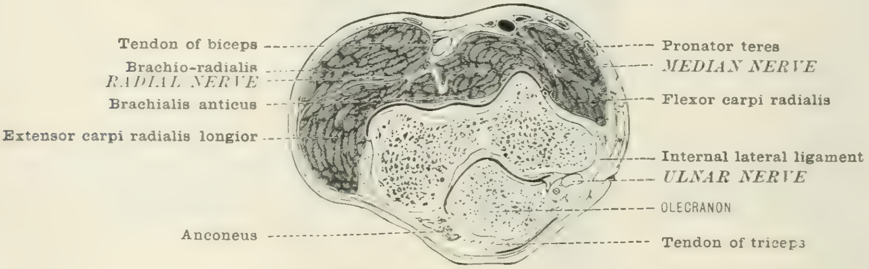
The **centre of the arm** is a landmark for many anatomical structures. On the outer side is the insertion of the deltoid; on the inner that of the coraco-brachialis. The basilic vein and the nerve of Wrisberg here perforate the deep fascia, going in reverse directions. The inferior profunda is here given off from the brachial; the median nerve also crosses the artery, and the ulnar nerve leaves the inner side of the vessel to pass to the inner aspect of the limb.

The **brachialis anticus** can be mapped out by two pointed processes which surround the insertion of the deltoid, and which pass downwards into lines corresponding to the two intermuscular septa, and then converge over the front of the elbow to their insertion into the coronoid process.

The **median nerve** can be traced by a line drawn from the outer side of the third part of the axillary and first part of the brachial artery, across this latter vessel about its centre, and then along its inner border to the forearm, where it passes between the two heads of the pronator radii teres.

The **ulnar nerve** lies to the inner side of the above arteries as far as the middle of the arm, where it leaves the brachial to course more inwards and perforate the internal intermuscular septum and get to the back of the internal condyle.

FIG. 717.—VERTICAL SECTION OF THE ELBOW. (One-half.) (Braune.)



The **musculo-spiral nerve** can be traced by a line beginning behind the third part of the axillary artery, then carried vertically down behind the uppermost part of the brachial, and then, just below the posterior border of the axilla, curving backwards behind the humerus and slightly downwards, just below the insertion of the deltoid. Thus, passing from within outwards and from before backwards in its groove with the superior profunda vessels, it again comes to the front by perforating the external intermuscular septum at a point about opposite to the junction of the middle and lower thirds of the arm, and passes down in front of the external supracondyloid ridge, lying here between the brachio-radialis and brachialis anticus, to the level of the external condyle, where it divides into radial and posterior interosseous. The former of these accompanies the radial artery to the front of the arm, the latter travels backwards to the back of the forearm.

On the back of the arm is the **triceps muscle,** with its three heads and tendon of insertion, all brought into relief in a muscular subject when the forearm is strongly extended. Of the three heads, the inner is the least distinct, arising below the musculo-spiral groove, reaching to each intermuscular septum, and tapering away above as high as the teres major. The outer head, arising above the groove as high as the great tuberosity, appears in strong relief just below the deltoid; while the middle or long head, arising from the scapula just below the glenoid cavity, appears between the teres muscles. The tendon of insertion, passing into the upper and back part of the olecranon over a deep bursa, is shown by a somewhat depressed area.

THE ELBOW

The **bony points,** condyles, olecranon, and head of radius, and their relation to one another, should be carefully studied. The internal condyle is the more prominent of the two, is directed backwards as well as inwards, and lies a little above its fellow. Above it can be traced upwards the supracondyloid ridge and correspond-

FIG. 718.—LONGITUDINAL SECTION OF THE ELBOW-JOINT. (One-half.) (Braune.)

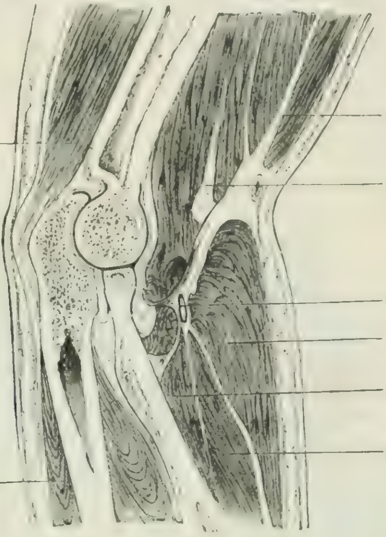
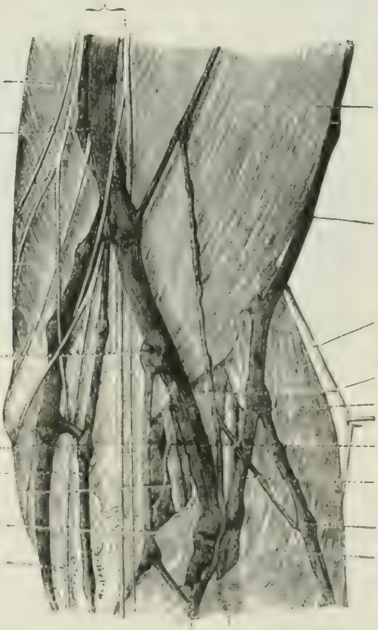

Biceps
Triceps
Brachialis anticus
MUSCULO-SPIRAL NERVE
Brachio-radialis
Supinator brevis
Extensor carpi radialis longior
Extensor carpi ulnaris

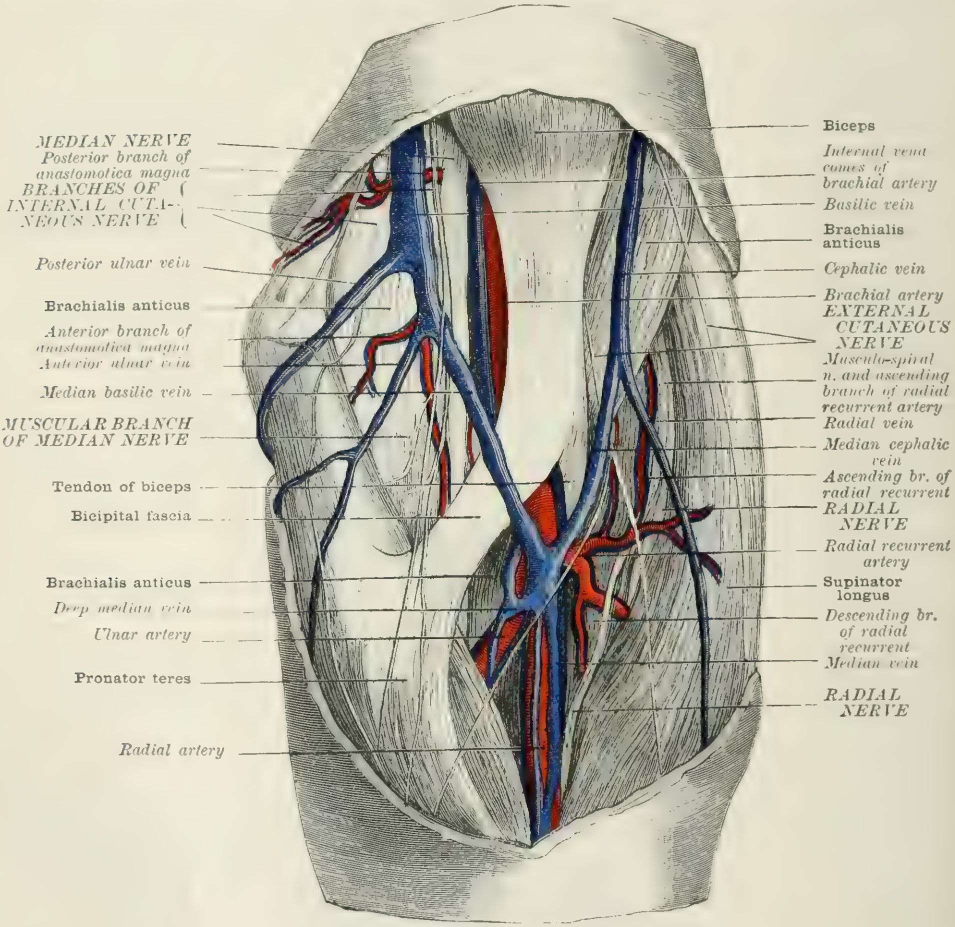
FIG. 719.—BEND OF THE ELBOW. (One-half.) (Blandin.)


INTERNAL CUTANEOUS NERVE
Brachial aponeurosis
Brachial aponeurosis
Basilic vein
Cephalic vein
CUTANEOUS BRANCH OF MUSCULO-SPIRAL NERVE
Median basilic vein
Slip of brachial aponeurosis passing to muscles attached to external condyle
EXTERNAL CUTANEOUS NERVE
Epitrochlea
Abnormal vessel
Abnormal vessel
Superficial ulnar vein
Median cephalic vein
Brachial artery and venæ comites
Bicipital fascia
Superficial radial vein
Anti-brachial aponeurosis
Anti-brachial aponeurosis
Deep radial vein
Median vein

ing septum. The external condyle is more rounded, and thus less prominent; below, and a little behind it, the head of the radius can be felt moving under the capitellum when the forearm is supinated and flexed. A depression marks this spot and corresponds to the interval between the anconeus and brachio-radialis and exterior carpi radialis longior; at the back, the upper part of the olecranon is covered by the triceps. The lower is subcutaneous, and separated from the skin by a bursa. If the thumb and second finger be placed on the condyles and the index on the tip of the olecranon, and the forearm completely extended, the tip of the olecranon rises so as to be on the line joining the two condyles. In

FIG. 720.—THE BEND OF THE ELBOW WITH THE SUPERFICIAL VEINS.

(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)

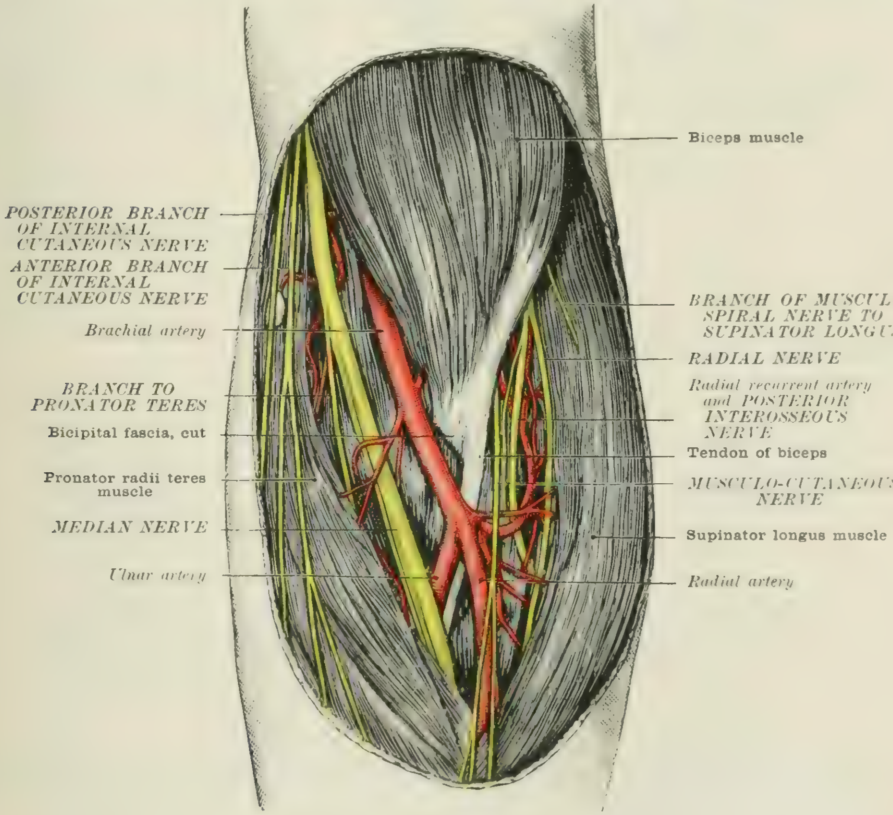

MEDIAN NERVE
Posterior branch of anastomotica magna
BRANCHES OF INTERNAL CUTANEOUS NERVE
Posterior ulnar vein
Brachialis anticus
Anterior branch of anastomotica magna
Anterior ulnar vein
Median basilic vein
MUSCULAR BRANCH OF MEDIAN NERVE
Tendon of biceps
Bicipital fascia
Brachialis anticus
Deep median vein
Ulnar artery
Pronator teres
Radial artery
Biceps
Internal vena comes of brachial artery
Basilic vein
Brachialis anticus
Cephalic vein
Brachial artery
EXTERNAL CUTANEOUS NERVE
Musculo-spiral n. and ascending branch of radial recurrent artery
Radial vein
Median cephalic vein
Ascending br. of radial recurrent
RADIAL NERVE
Radial recurrent artery
Supinator longus
Descending br. of radial recurrent
Median vein
RADIAL NERVE

flexion at a right angle, the olecranon is below the line of the condyles, and in complete flexion quite in front of them. Between the inner condyle and olecranon is a pit, in which lie the ulnar nerve and the anastomosis between the inferior profunda and the posterior ulnar recurrent arteries. The coronoid process is so well covered by muscles, vessels, and nerves, that its position cannot be distinctly made out.

Swelling, due to effusion into the joint, appears on either side of the triceps tendon, and soon obliterates the depression below the external condyle. A superficial swelling over the tip of the olecranon is due to effusion into the bursa between the soft parts and that bone. A deeper, less easily defined, swelling in the same region is due to inflammation of the bursa between the olecranon and the triceps. A swelling on the inner side of the elbow-joint, if painful and accompanied by inflammation of the skin, may be due to mischief in the **epitrochlear gland** situated just above the internal condyle, and receiving lymphatics from the inner border of the forearm and the two inner fingers.

The hollow in front of the elbow.—The delicacy of the skin here must always be borne in mind in the application of splints. The **M-like arrangement of the superficial veins** as usually described is by no means constant (figs. 719, 720). The median basilic is the vein usually chosen for venesection, owing to its larger size and its being firmly supported by the subjacent bicipital fascia which separates it from the brachial artery; but the median cephalic is the safer. The median basilic is crossed by branches of the internal cutaneous nerve, while those of the musculo-cutaneous lie under the median cephalic. In the semiflexed position, the fold of the elbow is seen, a little above the level of the joint. This forms the base of the triangular fossa below the elbow, the outer side corresponding to the brachio-radialis, the inner to the pronator radii teres, and the apex to the meeting of these muscles. The tendon of the biceps can be easily made out in the centre of the fossa, giving off above the bicipital fascia from its inner side to fasten down the flexors of the forearm. Under the tendon on its inner side lie the brachial artery and the median nerve for a short distance. The musculo-spiral lies outside the fossa, between the brachio-radialis and the brachialis anticus. The brachial **usually bifurcates opposite to the neck of the radius.**

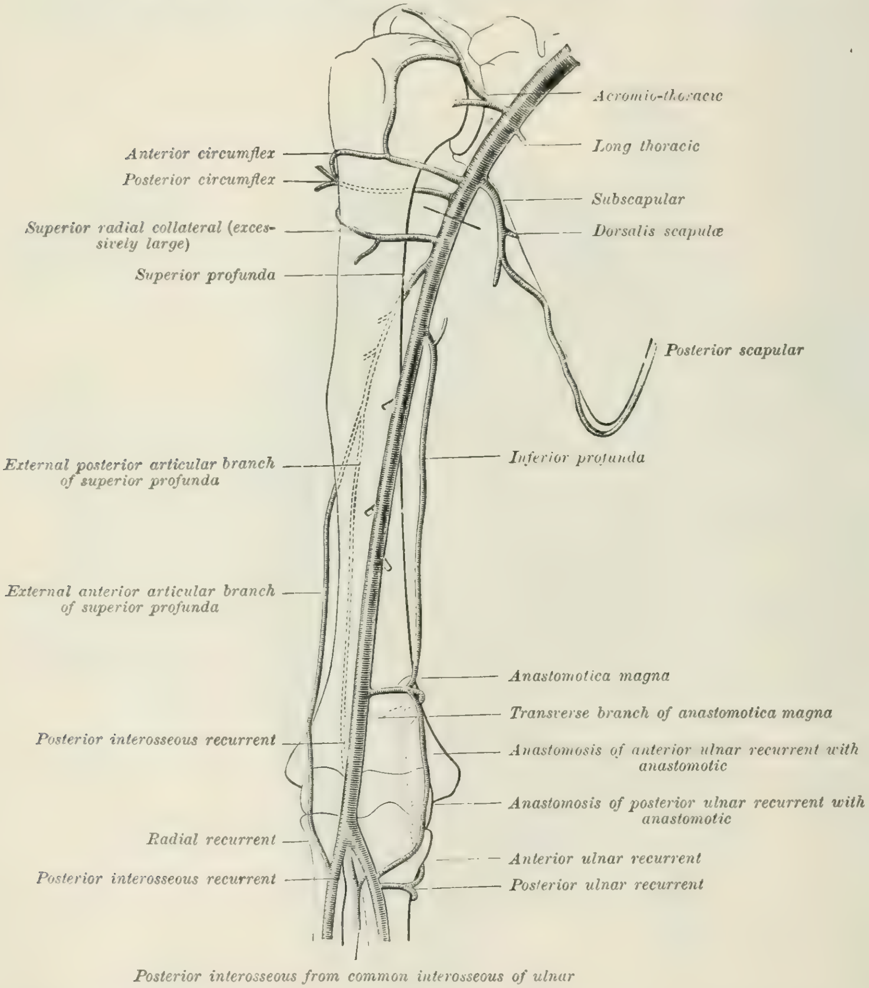
FIG. 721.—THE BRACHIAL ARTERY AT THE BEND OF THE ELBOW.



Biceps muscle
POSTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
ANTERIOR BRANCH OF INTERNAL CUTANEOUS NERVE
Brachial artery
BRANCH OF MUSCULO-SPIRAL NERVE TO SUPINATOR LONGUS
RADIAL NERVE
BRANCH TO PRONATOR TERES
Radial recurrent artery and POSTERIOR INTEROSSEOUS NERVE
Bicipital fascia, cut
Tendon of biceps
Pronator radii teres muscle
MUSCULO-CUTANEOUS NERVE
MEDIAN NERVE
Supinator longus muscle
Ulnar artery
Radial artery

The **arterial anastomoses about the elbow-joint** are as follow: The radial recurrent runs up under cover of the brachio-radialis to anastomose with the superior profunda. The anterior ulnar recurrent ascends on the brachialis anticus to join the anastomotica magna under the pronator radii teres. The posterior ulnar recurrent makes for the interval between the internal condyle and the olecranon, to join with the inferior profunda and anastomotica magna. The posterior interosseous recurrent ascends, between the supinator brevis and the anconeus, to anastomose on the back of the external condyle with the superior profunda. It further joins, by a large anastomotic arch across the back of the joint, with the anastomotica magna and posterior ulnar recurrent.

FIG. 722.—DIAGRAM OF THE ANASTOMOSES OF THE BRACHIAL ARTERY. (MacCormac and Anderson.)


Acromio-thoracic
Long thoracic
Anterior circumflex
Posterior circumflex
Subscapular
Superior radial collateral (excessively large)
Dorsalis scapulæ
Superior profunda
Posterior scapular
External posterior articular branch of superior profunda
Inferior profunda
External anterior articular branch of superior profunda
Anastomotica magna
Transverse branch of anastomotica magna
Posterior interosseous recurrent
Anastomosis of anterior ulnar recurrent with anastomotic
Anastomosis of posterior ulnar recurrent with anastomotic
Radial recurrent
Anterior ulnar recurrent
Posterior interosseous recurrent
Posterior ulnar recurrent
Posterior interosseous from common interosseous of ulnar

The following **table of the vessels anastomosing on the front and back of the condyles** will be useful:—

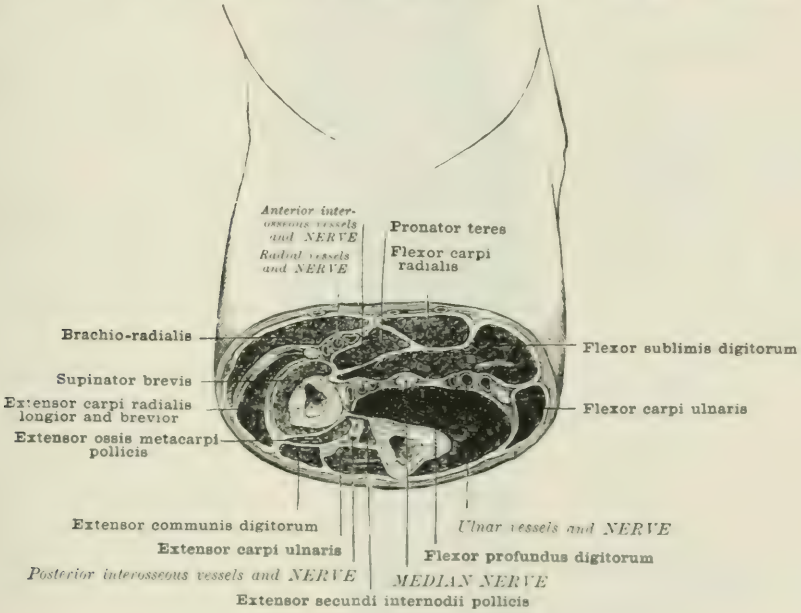
Internal condyle	*Front.*	—Anastomotica magna. Anterior ulnar recurrent. Inferior profunda.
	Back.	—Anastomotica magna. Posterior ulnar recurrent. Inferior profunda.
External condyle	*Front.*	—Superior profunda. Radial recurrent.
	Back.	—Superior profunda. Anastomotica magna. Interosseous recurrent.

It will be seen that the anastomotica magna is the artery most largely employed, distributing branches everywhere, save to the front of the external condyle.

THE FOREARM

Bony landmarks.—The ulna can be easily traced down from the olecranon to the styloid process; the bone becomes somewhat rounded below, and lies between the flexor and extensor carpi ulnaris. The tip of the styloid process corresponds to the inner end of the line of the wrist-joint. The radius is covered above by the brachio-radialis and radial extensors of the carpus, and the outline of the bone is less easily followed. Its styloid process is readily made out below, a finger's breadth above the thenar eminence. It is placed on a slightly lower level than that of the styloid process of the ulna. Thus, a line drawn straight between the two processes would fall a little below that of the wrist-joint, this being shown by a line drawn between the two processes forming a slight curve, with its concavity downwards (corresponding to the concavity of the lower surface of the radius and fibro-cartilage) about half an inch (12 mm.) above the straight line given above.

Fig. 723.—Section through the Middle of the Right Forearm. (Heath.)


Anterior interosseous vessels and NERVE
Radial vessels and NERVE
Pronator teres
Flexor carpi radialis
Brachio-radialis
Supinator brevis
Extensor carpi radialis longior and brevior
Extensor ossis metacarpi pollicis
Flexor sublimis digitorum
Flexor carpi ulnaris
Extensor communis digitorum
Extensor carpi ulnaris
Posterior interosseous vessels and NERVE
Extensor secundi internodii pollicis
Ulnar vessels and NERVE
Flexor profundus digitorum
MEDIAN NERVE

The radial styloid process is covered by the extensor ossis metacarpi and primi internodii pollicis, while farther out lies that of the extensor secundi. The bones are nearest to each other in complete pronation, and farthest apart in complete supination. On section, the bones are found at every point nearer to the back than to the front of the limb, but increasingly so above. 'The lower the section proceeds down the limb, the less will the bones be covered at the sides, and the more equally will the soft parts be distributed about the anterior and posterior aspects of the limb. It will be noticed that where one bone is the most substantial, the other is the more slender, as near the elbow and wrist; and that it is about the centre of the limb that the two are most nearly of equal strength' (Treves). When the limb is pronated, the interosseous space is narrowed; in supination and the mid-position it is widened out. In pronation, both styloid processes can be distinctly made out; in supination, that of the radius is most distinct, as now the skin and soft parts are stretched and raised over that of the ulna.

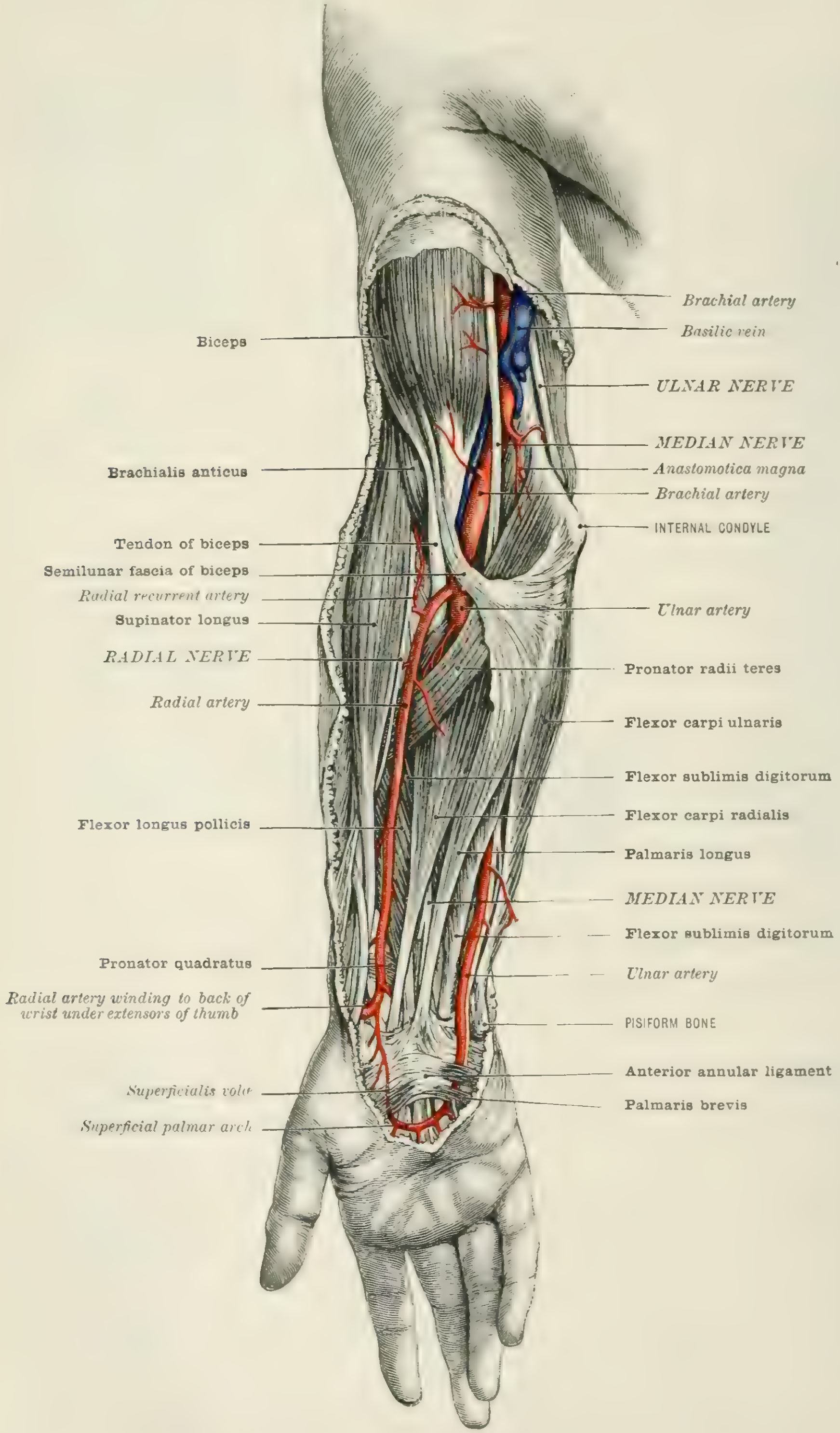


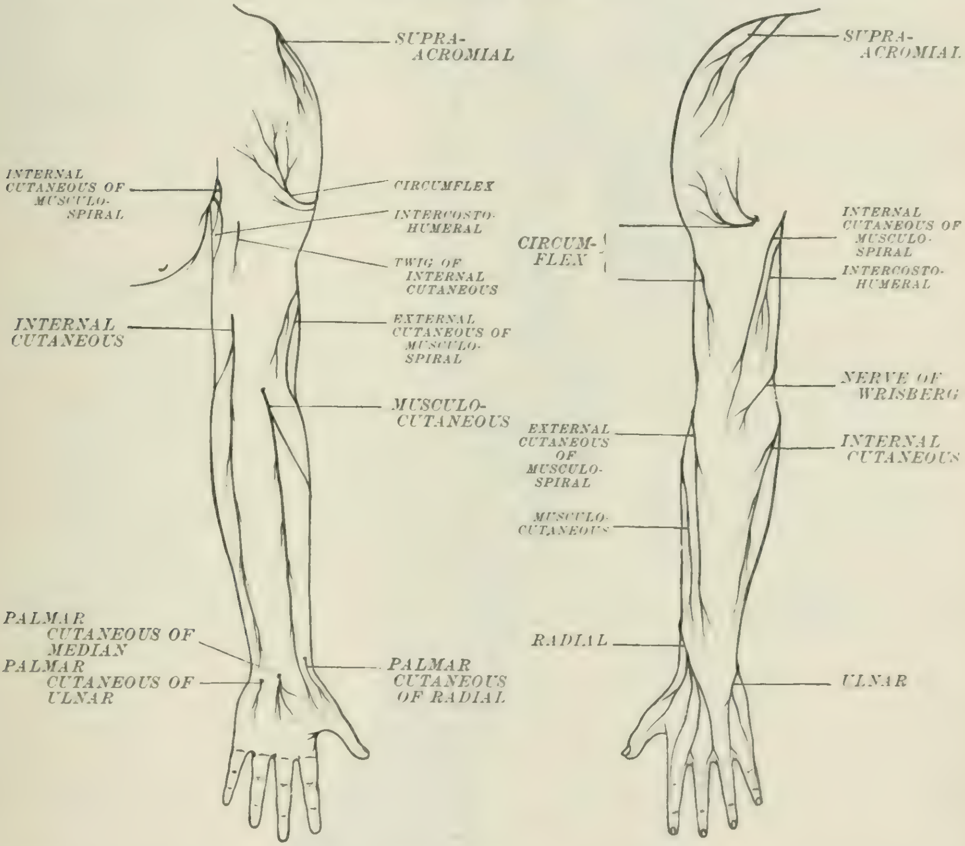
FIG. 724.—THE ARTERIES OF THE FOREARM WITH THE SUPERFICIAL PALMAR ARCH.

Biceps
Brachialis anticus
Tendon of biceps
Semilunar fascia of biceps
Radial recurrent artery
Supinator longus
RADIAL NERVE
Radial artery
Flexor longus pollicis
Pronator quadratus
Radial artery winding to back of wrist under extensors of thumb
Superficialis volæ
Superficial palmar arch
Brachial artery
Basilic vein
ULNAR NERVE
MEDIAN NERVE
Anastomotica magna
Brachial artery
INTERNAL CONDYLE
Ulnar artery
Pronator radii teres
Flexor carpi ulnaris
Flexor sublimis digitorum
Flexor carpi radialis
Palmaris longus
MEDIAN NERVE
Flexor sublimis digitorum
Ulnar artery
PISIFORM BONE
Anterior annular ligament
Palmaris brevis

Soft parts.—Along the outer border descend the brachio-radialis and radial extensors of the carpus, fleshy above, tendinous below. About an inch and a half above the styloid process of the radius, a fleshy swelling directed obliquely downwards and forwards from behind, across this outer border of the forearm, denotes the extensors of the thumb crossing those of the carpus.

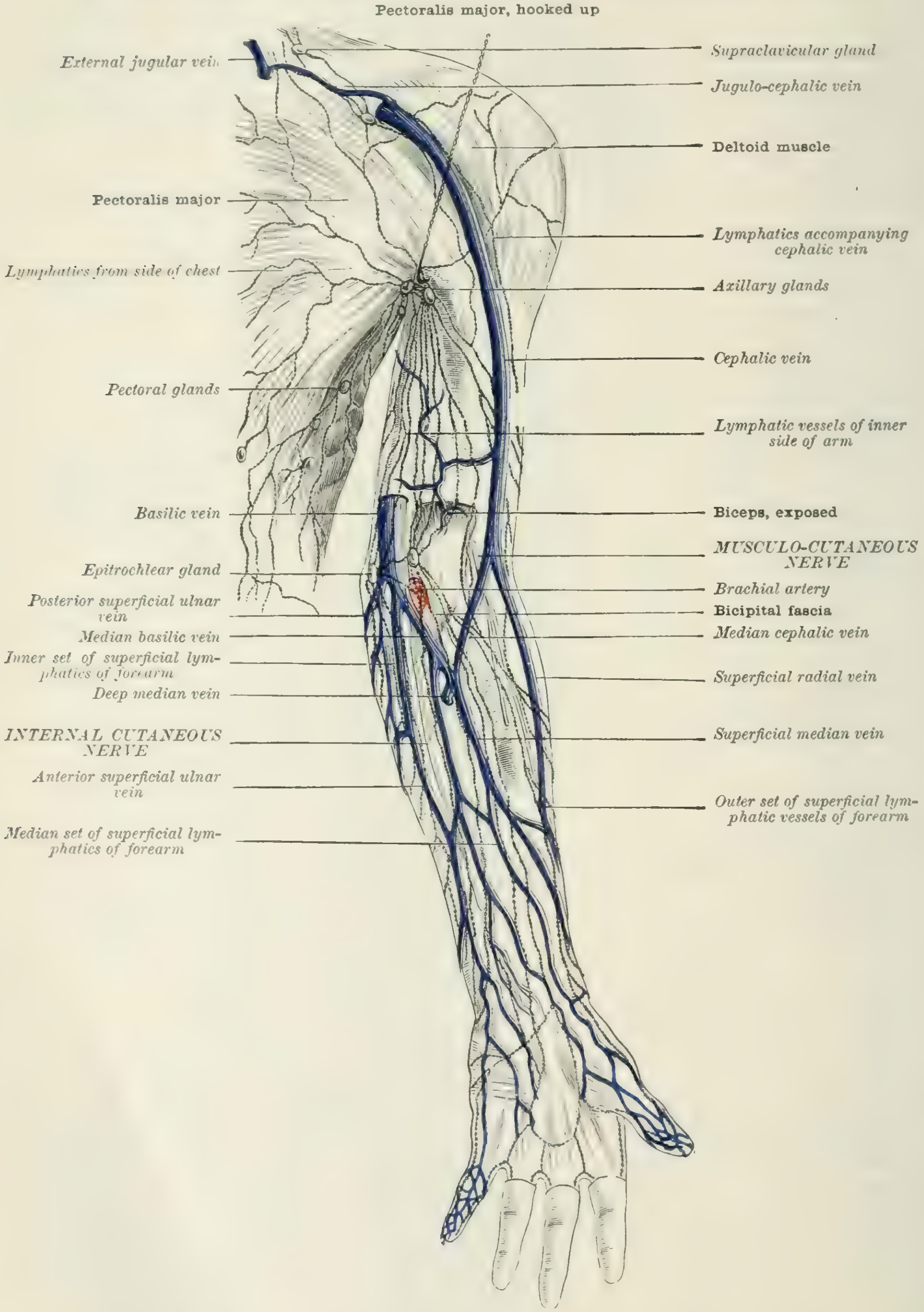
Along the inner border is the fleshy mass of the pronator teres and flexors, the ulna being covered by the flexor carpi ulnaris and flexor profundus. The tendon of the pronator is inserted into the radius a little below its centre—a point of importance in the treatment of fractures, and in amputation. The flexor carpi ulnaris tendon can be felt just above the wrist making for the pisiform bone; and just external to it lies the **ulnar artery**, about to pass over the anterior annular ligament. The course of the artery is denoted by a line drawn from the front of the internal condyle to the outer edge of the pisiform bone. If it be drawn from the bifurcation of the brachial, this line must in its upper third be made strongly convex inwards, in order to mark the upper part of the artery, here thickly covered by muscles. The line of the **ulnar nerve** is one drawn from the interval between the internal condyle and the olecranon to the inner side of the ulnar artery just above the wrist. The nerve joins the artery at the junction of the upper and middle thirds of the forearm. The **median nerve** runs in a line drawn from the inner side of the brachial artery, in the elbow triangle, to a point beneath, or just to the inner side of, the palmaris longus just above the wrist. The **radial artery** will be marked by a line drawn from the centre of the bend of the elbow (where the brachial artery divides opposite to the neck of the radius) to a point just

FIG. 725.—DISTRIBUTION OF CUTANEOUS NERVES ON THE ANTERIOR AND POSTERIOR ASPECTS OF THE SUPERIOR EXTREMITY.


SUPRA-ACROMIAL
INTERNAL CUTANEOUS OF MUSCULO-SPIRAL
CIRCUMFLEX
INTERCOSTO-HUMERAL
TWIG OF INTERNAL CUTANEOUS
INTERNAL CUTANEOUS
EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
MUSCULO-CUTANEOUS
PALMAR CUTANEOUS OF MEDIAN
PALMAR CUTANEOUS OF ULNAR
PALMAR CUTANEOUS OF RADIAL
SUPRA-ACROMIAL
CIRCUM-FLEX
INTERNAL CUTANEOUS OF MUSCULO-SPIRAL
INTERCOSTO-HUMERAL
NERVE OF WRISBERG
INTERNAL CUTANEOUS
EXTERNAL CUTANEOUS OF MUSCULO-SPIRAL
MUSCULO-CUTANEOUS
RADIAL
ULNAR

internal to the radial styloid process descending along the inner edge of the brachioradialis. The **radial nerve** will be marked by the same line (it lies just external to the artery) for its upper two-thirds; it then leaves the artery about three inches above the wrist-joint, and passes to the back of the forearm under the tendon of

Fig. 726.—Superficial Veins and Lymphatics of the Forearm and Arm.

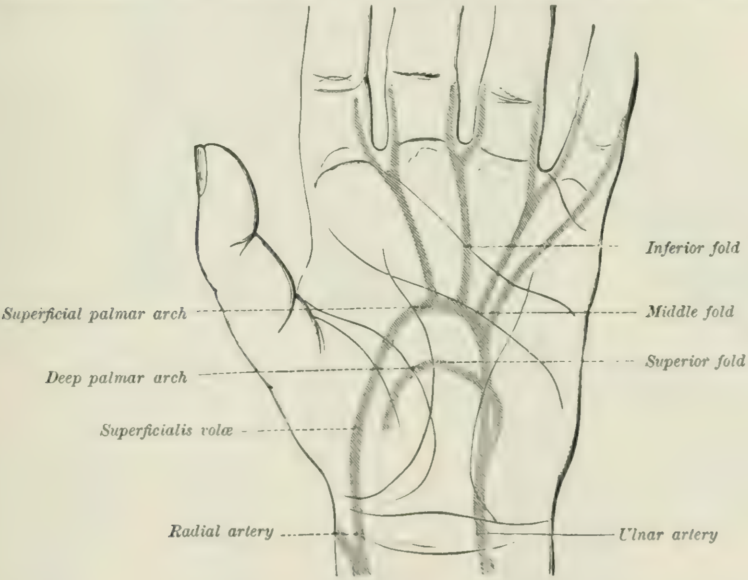

Pectoralis major, hooked up
External jugular vein
Pectoralis major
Lymphatics from side of chest
Pectoral glands
Basilic vein
Epitrochlear gland
Posterior superficial ulnar vein
Median basilic vein
Inner set of superficial lymphatics of forearm
Deep median vein
INTERNAL CUTANEOUS NERVE
Anterior superficial ulnar vein
Median set of superficial lymphatics of forearm
Supraclavicular gland
Jugulo-cephalic vein
Deltoid muscle
Lymphatics accompanying cephalic vein
Axillary glands
Cephalic vein
Lymphatic vessels of inner side of arm
Biceps, exposed
MUSCULO-CUTANEOUS NERVE
Brachial artery
Bicipital fascia
Median cephalic vein
Superficial radial vein
Superficial median vein
Outer set of superficial lymphatic vessels of forearm

the brachio-radialis. The **anterior interosseous artery** runs down on the interosseous membrane and passes to the back of the forearm by perforating it below. The **posterior interosseous** lies between the superficial and deep extensors. These small arteries reinforce the palmar through the carpal arches, and thus bring down blood after ligature of the trunks above.

The front of the forearm is supplied by the musculo-cutaneous on the outer, and the internal cutaneous on the inner side; just above the wrist the palmar cutaneous branches of the median and ulnar perforate the deep fascia (fig. 725). The back of the forearm is supplied by the musculo-spiral and posterior branches of the musculo-cutaneous externally, and the posterior branches of the internal cutaneous internally (fig. 725). The arrangement of the superficial lymphatics, shown in fig. 726, may be briefly described as follows:—

The **lymphatics of the upper extremity** are **superficial** and **deep**; the former run with the superficial veins, the latter with the deep vessels. As a rule, there are no **glands** below the elbow. The majority of the lymphatics open into the axillary glands, and terminate on the left side, in the thoracic duct, on the right, in the right lymphatic duct. A few, accompanying the cephalic vein, reach the subclavian or infraclavicular glands, and thus communicate with the lymphatics of the neck.

FIG. 727.—RELATION OF THE PALMAR ARCHES TO THE FOLDS OF THE PALM. (Tillaux.)



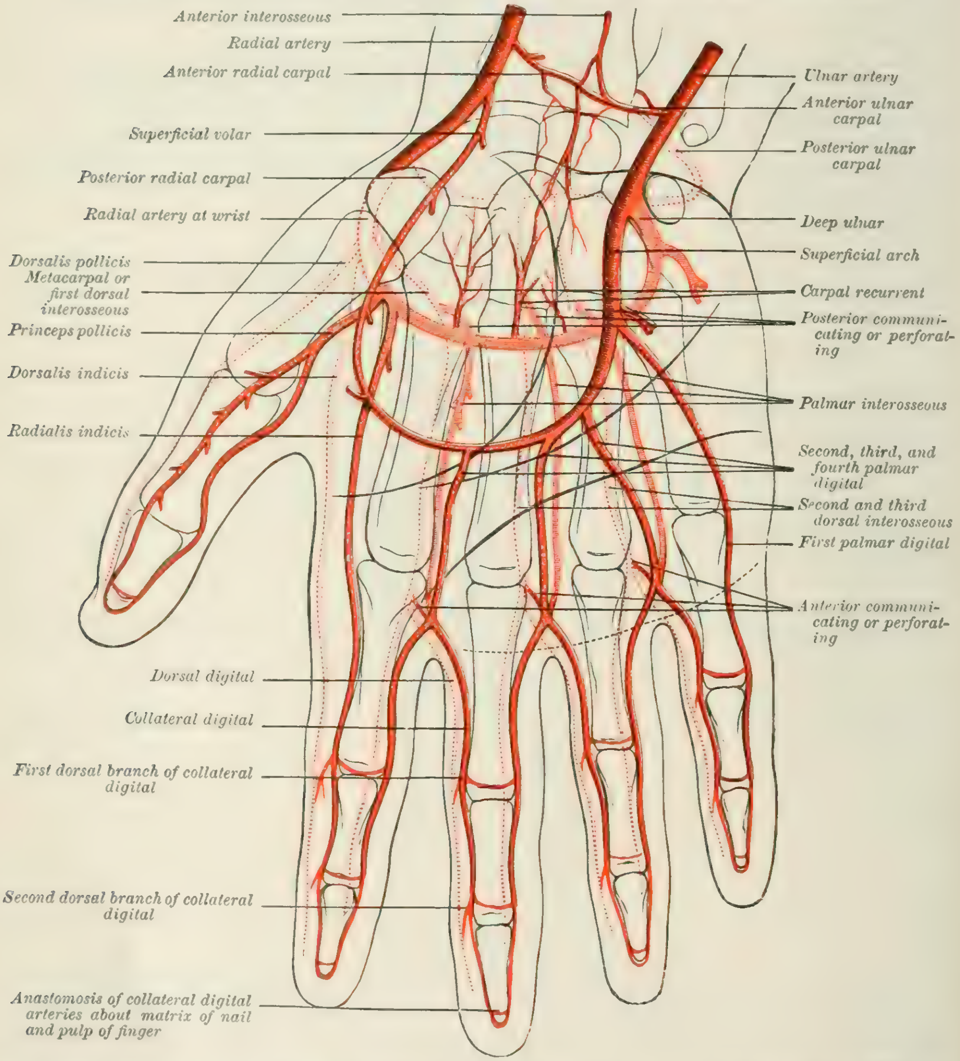
THE WRIST AND HAND

Bony points.—On the inner side, the styloid process and, farther outwards, the head of the ulna can be made out. On the outer side, the radial styloid process descends about half an inch (12 mm.) lower than that of the radius, and is somewhat anterior to it. Abduction of the hand is thus less free than adduction. In Colles' fracture, the line of fracture, usually transverse, crosses the radius about an inch above the apex of the styloid process. Between the apex of the styloid process and the ball of the thumb a bony ridge can be felt, with some difficulty, formed by the tubercle of the scaphoid and the ridge of the trapezium. At a corresponding point on the inner side the pisiform can be more readily distinguished. On the front of the metacarpo-phalangeal joint of the thumb the sesamoid bones can be distinguished.

At the back of the wrist and hand the cuneiform bone can be felt below the head of the ulna; and more towards the middle line the prominence of the os magnum, which supports the third or longest digit, and is the bone of the carpus most exposed to injury. A line drawn from the base of the fifth metacarpal bone to the radio-carpal joint, slightly curved downwards, will give the line of the **carpo-metacarpal joints** (Windle).

When the fingers are flexed, it will be seen that in each case it is the proximal bone which forms the prominence; thus, the knuckle is formed by the head of the metacarpal the interphalangeal prominence by the head of the first phalanx, and the distal one by the head of the second. Thus, the joint in each case lies below the prominence, the distal joint being one-twelfth of an inch (2 mm.), the interphalangeal one-sixth (4 mm.), and the metacarpo-phalangeal one-third (8 mm.) below its prominence.

Fig. 728.—Anastomoses and Distribution of the Arteries of the Hand.

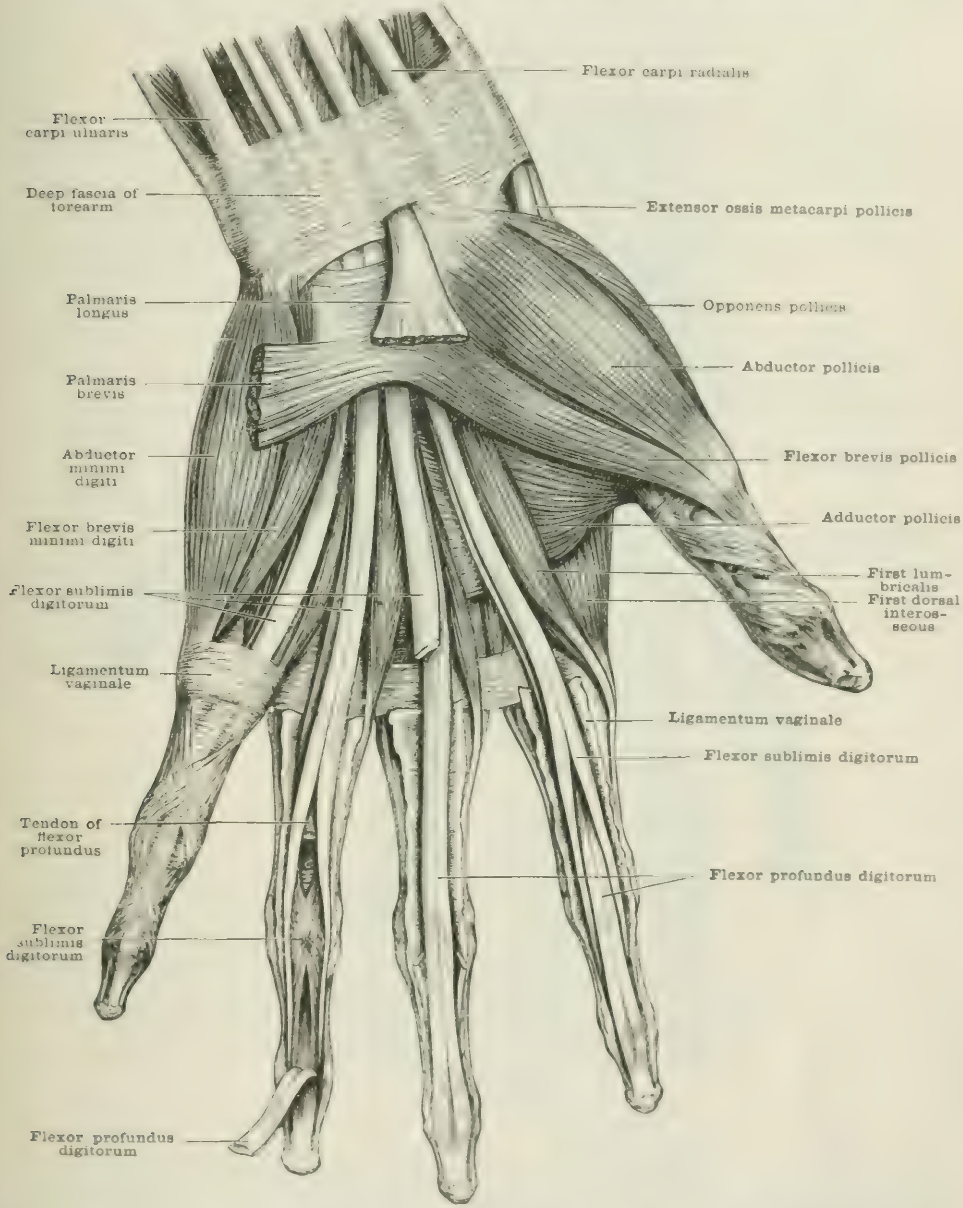

Anterior interosseous
Radial artery
Anterior radial carpal
Superficial volar
Posterior radial carpal
Radial artery at wrist
Dorsalis pollicis
Metacarpal or first dorsal interosseous
Princeps pollicis
Dorsalis indicis
Radialis indicis
Dorsal digital
Collateral digital
First dorsal branch of collateral digital
Second dorsal branch of collateral digital
Anastomosis of collateral digital arteries about matrix of nail and pulp of finger
Ulnar artery
Anterior ulnar carpal
Posterior ulnar carpal
Deep ulnar
Superficial arch
Carpal recurrent
Posterior communicating or perforating
Palmar interosseous
Second, third, and fourth palmar digital
Second and third dorsal interosseous
First palmar digital
Anterior communicating or perforating

Skin folds.—Two or three of these are seen on the palmar surface of the wrist; two lower down, and usually close together; and one less well marked a little higher up upon the forearm. None of these correspond exactly to the wrist-joint (page 1159). The lowest 'precisely crosses the arch of the os magnum in the line of the third metacarpal bone' (Tillaux), and is not quite three-quarters of an inch

(18 mm.) below the arch of the wrist-joint. It is about half an inch above the carpo-metacarpal joint line, and indicates very fairly the upper border of the **anterior annular ligament.**

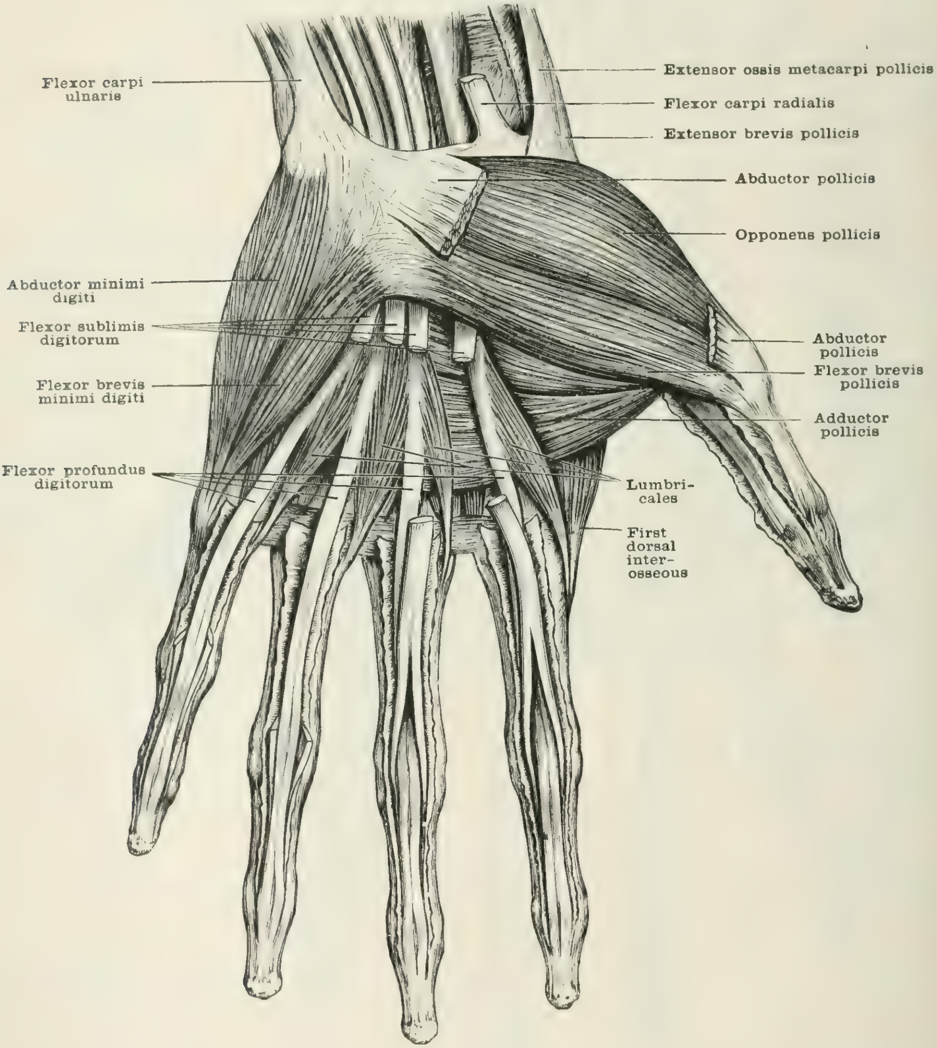
The **thenar** and **hypothenar eminences** are separated by a triangular interval with the apex upwards; this apex corresponds to the upper border of the anterior annular ligament. Of the many creases in the skin of the palm, three require especial notice. The first starts at the wrist, between the thenar and hypothenar eminences, and, marking off the former eminence from the palm, ends at the outer border of the hand and at the base of the index finger. The second fold is slightly marked. It starts from the outer border of the hand, where the first fold ends. It

FIG. 729.—THE SUPERFICIAL MUSCLES OF THE PALM OF THE HAND.


Flexor carpi radialis
Flexor carpi ulnaris
Deep fascia of forearm
Extensor ossis metacarpi pollicis
Palmaris longus
Opponens pollicis
Abductor pollicis
Palmaris brevis
Abductor minimi digiti
Flexor brevis pollicis
Adductor pollicis
Flexor brevis minimi digiti
First lumbricalis
Flexor sublimis digitorum
First dorsal interosseous
Ligamentum vaginale
Ligamentum vaginale
Flexor sublimis digitorum
Tendon of flexor profundus
Flexor profundus digitorum
Flexor sublimis digitorum
Flexor profundus digitorum

runs obliquely inwards across the palm, with a marked inclination towards the wrist, and ends at the outer limit of the hypothenar eminence. The third, lowest, and best-marked of the folds starts from the little elevation opposite the cleft between the index and middle fingers, and runs nearly transversely to the ulnar border of the hand, crossing the hypothenar eminence at the upper end of its lower fourth. An unimportant crease, running obliquely from the third to the second fold, gives to these markings the outline of the letter M. The first fold is produced by the adduction of the thumb; the second, mainly by the bending simultaneously of the metacarpo-phalangeal joints of the first and second fingers; and the third by the flexion of the three inner fingers. The second fold, as it crosses the third metacarpal bone, about corresponds to the lowest part of the superficial palmar arch. The third fold crosses the necks of the metacarpal bones, and indicates pretty nearly the upper limits of the synovial sheaths for the flexor tendons of the three outer fingers. A little way below this fold, the palmar fascia breaks up into its four slips, and midway between the fold and the webs of the fingers lie the metacarpo-phalangeal joints. Of the transverse folds across the fronts of the

Fig. 730.—The Deeper Muscles of the Palm of the Hand.


Flexor carpi ulnaris
Extensor ossis metacarpi pollicis
Flexor carpi radialis
Extensor brevis pollicis
Abductor pollicis
Opponens pollicis
Abductor minimi digiti
Flexor sublimis digitorum
Flexor brevis minimi digiti
Abductor pollicis
Flexor brevis pollicis
Adductor pollicis
Flexor profundus digitorum
Lumbricales
First dorsal interosseous

fingers, corresponding to the metacarpo-phalangeal and interphalangeal joints, the highest is placed nearly three-quarters of an inch (18 mm.) below its corresponding joint. The middle folds are multiple for all the fingers, and are exactly opposite to the first interphalangeal joints. The lowest creases are single, and are placed a little above the corresponding joints. There are two single creases on the thumb corresponding to the two joints, the higher crossing the metacarpo-phalangeal joint obliquely. The free edge of the web of the fingers, as measured from the palmar surface, is about three-quarters of an inch (18 mm.) from the metacarpo-phalangeal joints (Treves).

FIG. 731.—SECTION THROUGH REGION OF WRIST, A LITTLE ABOVE THE JOINT. RIGHT SIDE, UPPER HALF OF THE SECTION. (Tillaux.)

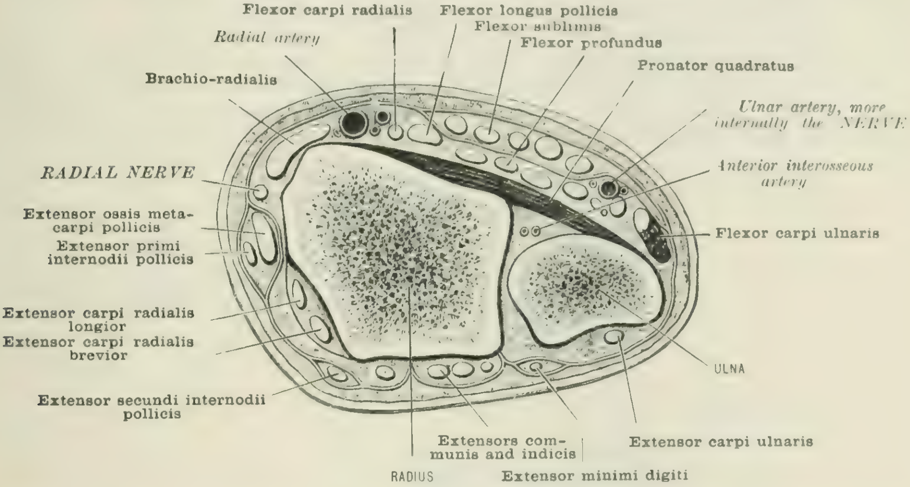
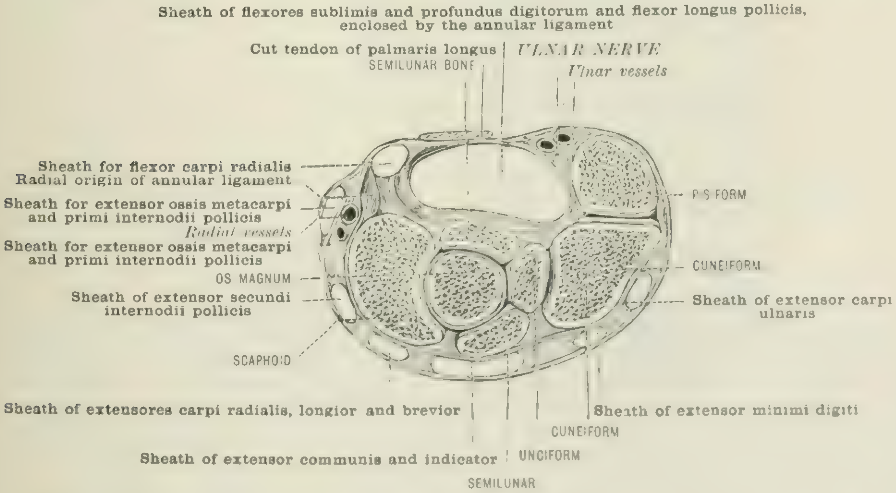

Flexor carpi radialis
Flexor longus pollicis
Flexor sublimis
Radial artery
Flexor profundus
Pronator quadratus
Brachio-radialis
Ulnar artery, more internally the NERVE
Anterior interosseous artery
RADIAL NERVE
Extensor ossis metacarpi pollicis
Extensor primi internodii pollicis
Flexor carpi ulnaris
Extensor carpi radialis longior
Extensor carpi radialis brevior
ULNA
Extensor secundi internodii pollicis
Extensors communis and indicis
Extensor carpi ulnaris
RADIUS
Extensor minimi digiti

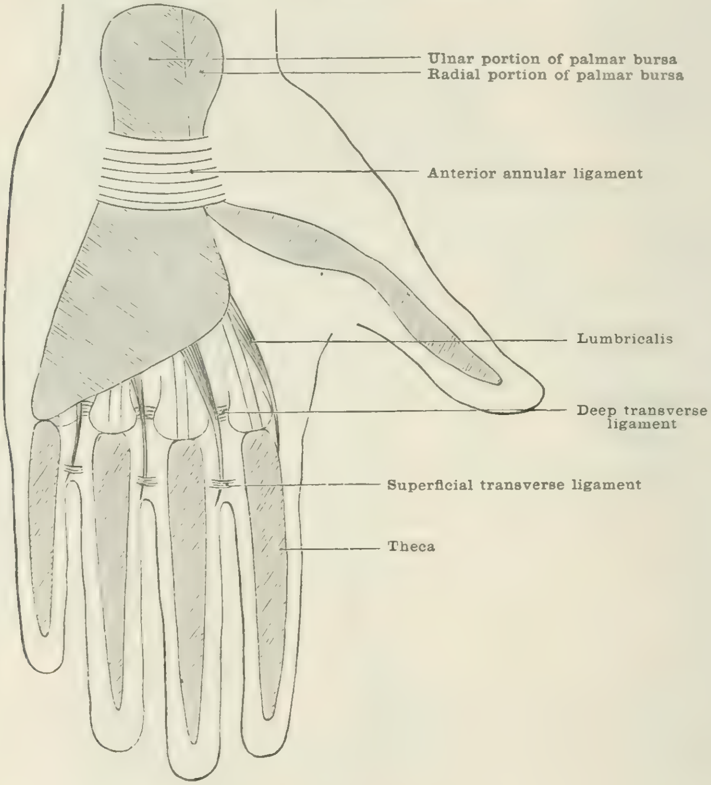
FIG. 732.—TRANSVERSE SECTION OF THE WRIST, THROUGH THE MIDDLE OF THE PISIFORM BONE.


Sheath of flexores sublimis and profundus digitorum and flexor longus pollicis, enclosed by the annular ligament
Cut tendon of palmaris longus
ULNAR NERVE
SEMILUNAR BONE
Ulnar vessels
Sheath for flexor carpi radialis
Radial origin of annular ligament
PISIFORM
Sheath for extensor ossis metacarpi and primi internodii pollicis
Radial vessels
Sheath for extensor ossis metacarpi and primi internodii pollicis
CUNEIFORM
OS MAGNUM
Sheath of extensor secundi internodii pollicis
Sheath of extensor carpi ulnaris
SCAPHOID
Sheath of extensores carpi radialis, longior and brevior
Sheath of extensor minimi digiti
CUNEIFORM
Sheath of extensor communis and indicator
UNCIFORM
SEMILUNAR

The **superficial palmar arch**, formed by the ulnar anastomosing with the superficialis volæ, or radialis indicis, will be shown by a line descending to the radial side of the pisiform bone, and then, a little lower, coming across the palm on a line with the thumb when outstretched at right angles with the index finger. The digital arteries, the main branches of the superficial arch run downwards along the interosseous spaces, and bifurcate half an inch above the webs of the fingers: the innermost digital does not bifurcate. The digital arteries then descend along the sides of the fingers under the digital nerves, giving off twigs to the sheath of the tendons, which enter by apertures in it, and run in the vincula vasculosa. It is owing to the readiness with which these tiny twigs are strangled by inflammation that sloughing of the tendon takes place so readily and irreparably. The **deep palmar arch,** formed by the radial and communicating branch of the ulnar, lies about half an inch nearer to the wrist than the superficial.

Fasciæ and sheaths.—The two **annular ligaments** bind down and hold in place the numerous tendons about the wrist. The **anterior,** when healthy, cannot be detected. It is attached to the pisiform and cuneiform bones on the inner, and to the scaphoid and trapezium on the outer, side. The ulnar nerve and vessels, the superficialis volæ, and palmar cutaneous branches of the median and ulnar pass over it. The ulnar artery and nerve are especially protected by their position between the pisiform and hook of the unciform, and also by a process of the flexor carpi ulnaris, which passes between the two bones, thus forming a kind of tunnel. The flexor carpi radialis passes through a separate sheath formed by the ligaments and the groove in the trapezium: while beneath the ligament lie the flexor tendons, the median nerve, and accompanying artery. Attached to its upper border is the deep fascia of the forearm, and to its lower the palmar fascia and the palmaris longus tendon, while from the outer and inner parts arise some of the thenar and hypothenar muscles. The upper border of the anterior annular ligament corresponds to the lower of the two lines which cross the wrist just above the thenar and hypothenar eminences. The large synovial sheath, for all the flexors of the fingers, reaches beneath and below the anterior ligament as far as the middle of the palm, and above the wrist for an inch and a half or two inches (37 to 50 mm.).

FIG. 733.—DIAGRAM OF THE GREAT PALMAR BURSA.


Ulnar portion of palmar bursa
Radial portion of palmar bursa
Anterior annular ligament
Lumbricalis
Deep transverse ligament
Superficial transverse ligament
Theca

The **posterior annular ligament** is attached to the back of the outer margin of the radius above the styloid process, and internally to the back of the cuneiform and pisiform. It contains six tendon-compartments, of which four are on the radius. The outermost contains the two first extensors of the thumb; the second the two radial extensors of the carpus; the third, the extensor secundi internodii; the fourth transmits the extensor communis and extensor indicis; the fifth, lying between the radius and ulna, the extensor minimi digiti; and the sixth, lying just outside the styloid process of the ulna, the extensor carpi ulnaris. The sheaths for the last two extensors are the only ones which follow the tendons to their insertion, the others ending at a varying distance below the annular ligament. The lower border of the posterior corresponds to the upper margin of the anterior annular ligament.

FIG. 734.—SECTION OF CARPUS, THROUGH THE UNCIFORM BONE. (Two-thirds.) (Bellamy after Henle.)

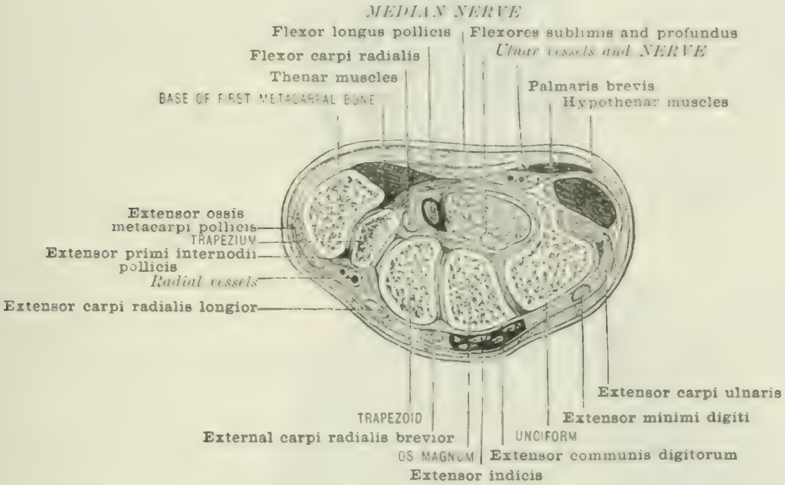
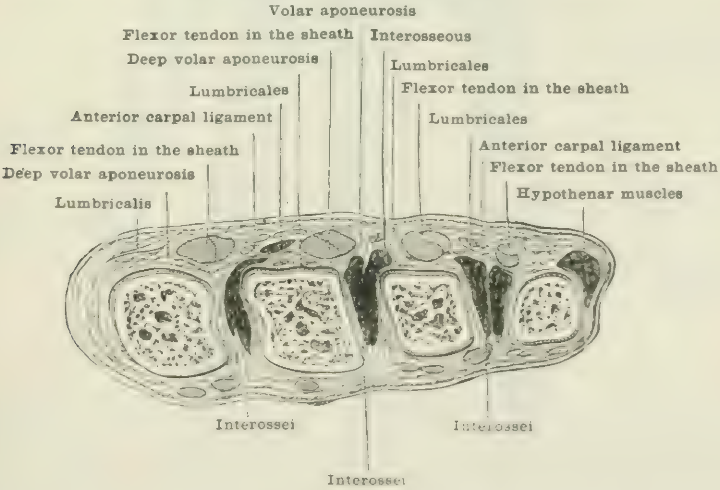
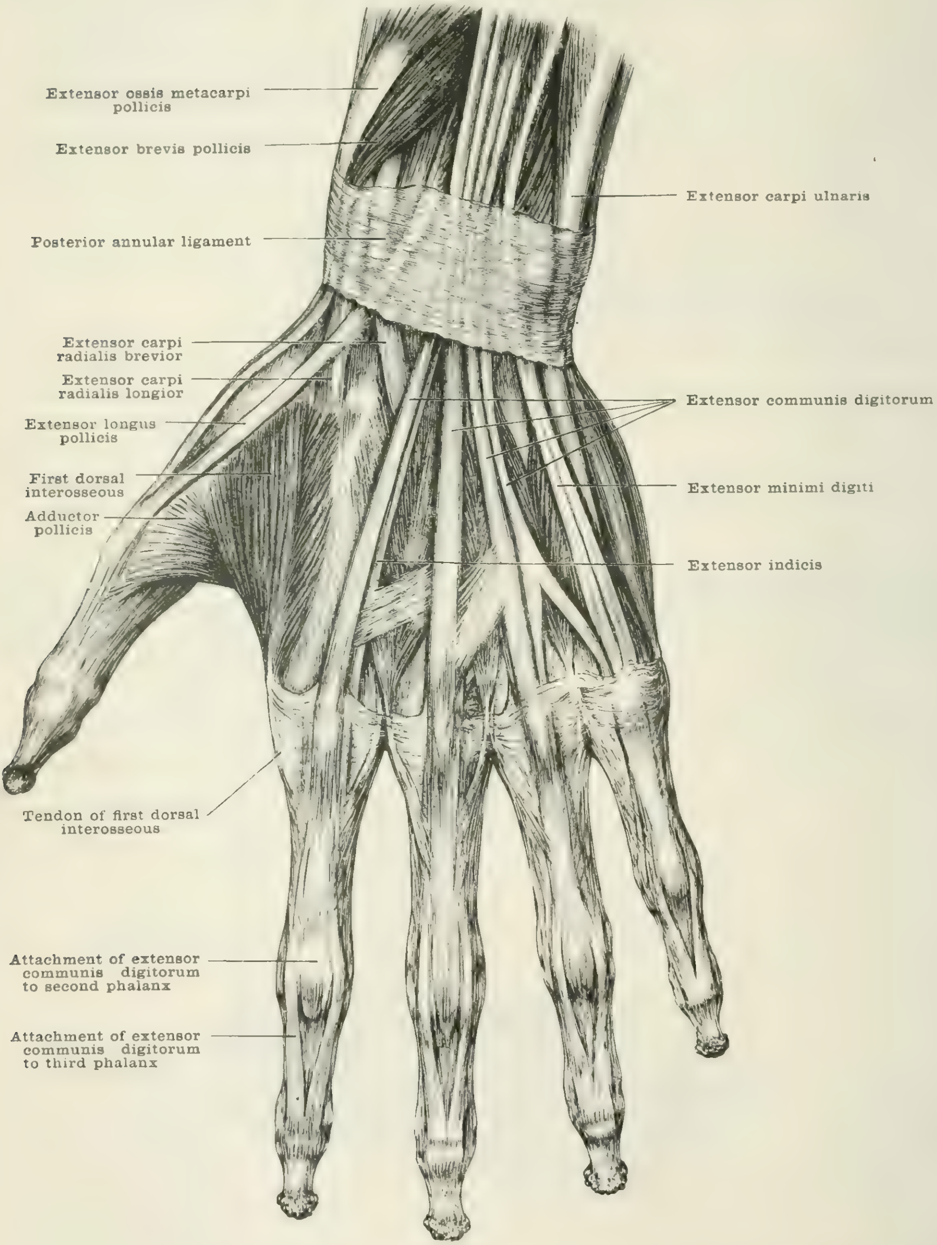

MEDIAN NERVE
Flexor longus pollicis
Flexores sublimis and profundus
Flexor carpi radialis
Ulnar vessels and NERVE
Thenar muscles
Palmaris brevis
BASE OF FIRST METACARPAL BONE
Hypothenar muscles
Extensor ossis metacarpi pollicis
TRAPEZIUM
Extensor primi internodii pollicis
Radial vessels
Extensor carpi radialis longior
Extensor carpi ulnaris
Extensor minimi digiti
TRAPEZOID
External carpi radialis brevior
UNCIFORM
OS MAGNUM
Extensor communis digitorum
Extensor indicis

FIG. 735.—HORIZONTAL SECTION OF THE HAND THROUGH THE CARPO-METACARPAL JOINTS. (Bellamy after Henle.)


Volar aponeurosis
Flexor tendon in the sheath
Interosseous
Deep volar aponeurosis
Lumbricales
Lumbricales
Flexor tendon in the sheath
Anterior carpal ligament
Lumbricales
Flexor tendon in the sheath
Anterior carpal ligament
Deep volar aponeurosis
Flexor tendon in the sheath
Lumbricalis
Hypothenar muscles
Interossei
Interossei
Interossei

The **palmar fascia**, by its strength, toughness, numerous attachments, and intimate connection with the superficial fascia and skin, is well adapted to protect the parts beneath from pressure. The thenar and hypothenar muscles are enclosed in two processes, which are thinner so as not to interfere with the contraction of the subjacent muscles. The central part, pointed above at its attachment to the annular ligaments, spreads out fan-like below, and gives off four slips, each of which bifurcates into two processes, which are attached to the sides of the first phalanx of each finger and into the transverse ligament which ties the heads of the metacarpal bones together. Transverse fibres pass between the processes into which each of the four slips bifurcates, and thus form the beginning of the theca, which is

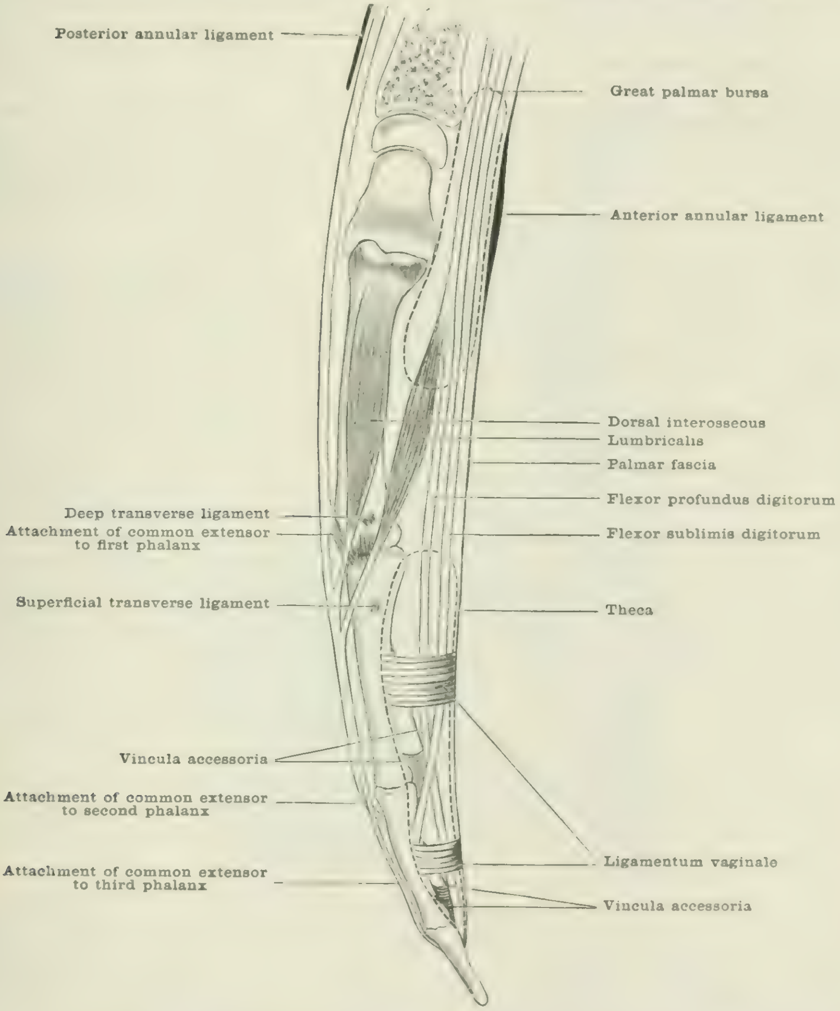
FIG. 736.—TENDONS UPON THE DORSUM OF THE HAND.


Extensor ossis metacarpi pollicis
Extensor brevis pollicis
Extensor carpi ulnaris
Posterior annular ligament
Extensor carpi radialis brevior
Extensor carpi radialis longior
Extensor communis digitorum
Extensor longus pollicis
First dorsal interosseous
Extensor minimi digiti
Adductor pollicis
Extensor indicis
Tendon of first dorsal interosseous
Attachment of extensor communis digitorum to second phalanx
Attachment of extensor communis digitorum to third phalanx

continued down to the finger to the base of the last phalanx. It is the contraction of the palmar fascia, especially of the slips to the two inner fingers, which gives rise to Dupuytren's contraction.

Synovial membranes.—Beneath the anterior annular ligament lie two **synovial sacs**, one for the flexor longus pollicis, and one for the superficial and deep flexors of the fingers. They extend above the annular ligament to from one and a quarter to one inch and a half (31 to 37 mm.) below. That for the long flexor of the thumb reaches to the base of the last phalanx. That for the finger-flexors gives off four processes. The one for the little finger also reaches to the base of the last phalanx. Those for the index, middle, and third fingers, end about the middle of the metacarpal bones. Traced from the insertions of the flexor profundus, the digital synovial sheaths extend upwards into the palm as far as the bifurcation of the palmar fascia (page 1169), i.e. into a point about opposite to the necks of the metacarpal bones, denoted on the surface by the crease which corresponds to the flexion of the fingers. Thus, about half an inch (12 mm.) separates the sheaths of the outer three fingers from that large synovial sac beneath the annular ligament. There is no synovial sheath beneath the pulp of the fingers or thumb,

FIG. 737.—DIAGRAM OF A VERTICAL SECTION THROUGH THE MIDDLE OF THE HAND.


Posterior annular ligament
Great palmar bursa
Anterior annular ligament
Dorsal interosseous
Lumbricalis
Palmar fascia
Flexor profundus digitorum
Deep transverse ligament
Attachment of common extensor to first phalanx
Flexor sublimis digitorum
Superficial transverse ligament
Theca
Vincula accessoria
Attachment of common extensor to second phalanx
Ligamentum vaginale
Attachment of common extensor to third phalanx
Vincula accessoria

this part lying on the periosteum of the last phalanx. The synovial sheaths, as they pass beneath the annular ligament, are somewhat constricted.

Deeper down are the **articular synovial sacs,** five in number: (1) Between the interarticular cartilage and the head of the ulna; (2) between the radius and the interarticular cartilage above, and the scaphoid, and semilunar and cuneiform below; (3) between the trapezium and first metacarpal bone; (4) between the pisiform and the cuneiform bone; (5) between the two rows of carpal bones, sending two processes upwards between the three bones of the upper row, and three downwards between the four of the lower row; these three processes being also continued below into the inner four carpo-metacarpal and three intermetacarpal joints.

Beneath the palmar fascia covering the thenar eminence are the following structures:—Superficialis volæ, abductor pollicis, opponens pollicis, radial head of short flexor, tendon of long flexor, ulnar head of short flexor, princeps pollicis, and radialis indicis arteries, metacarpal bone of the thumb, with the tendon of the flexor carpi radialis and trapezium.

Beneath the central part of the palmar fascia are the superficial arch and its digital branches; the ulnar and median nerves, with their branches; the flexors, superficial and deep, with their synovial sheath; and the lumbricales; then a layer of connective tissue (the only structure which prevents matter pent in by the palmar fascia from making its way back out through the dorsum), the deep arch, the interossei, and the metacarpal bones.

In the hypothenar eminence under the fascia are part of the ulnar artery and nerve, the abductor and flexor brevis minimi digiti, the opponens, the deep branch of the ulnar artery and nerve, and the fifth metacarpal bone.

The back of the wrist and hand.—The posterior annular ligament has already been described with the anterior. On the outer side is the so-called 'snuff-box space' (*tabatière anatomique* of Cloquet), a triangular hollow, bounded towards the radius by the two first extensors of the thumb, and towards the ulna by the extensor secundi internodii. The scaphoid and trapezium, with their dorsal ligaments, form the floor. In the roof lie the radial vein and branches of the radial nerve. More deeply is the artery following a line from the apex of the styloid process to the back of the interosseous space. The different tendons have already been given. Between the first two metacarpal bones is the first dorsal interosseous muscle, which forms a fleshy projection against the radial side of the index metacarpal, when the thumb and index are pressed together. On its palmar aspect is the adductor pollicis. Wasting of the former muscle is a ready indication of injury or disease of the ulnar nerve.

THE LOWER EXTREMITY

THE THIGH

Bony landmarks.—Many of these, such as the anterior superior spine of the ilium and the spine of the pubes, have already been mentioned.

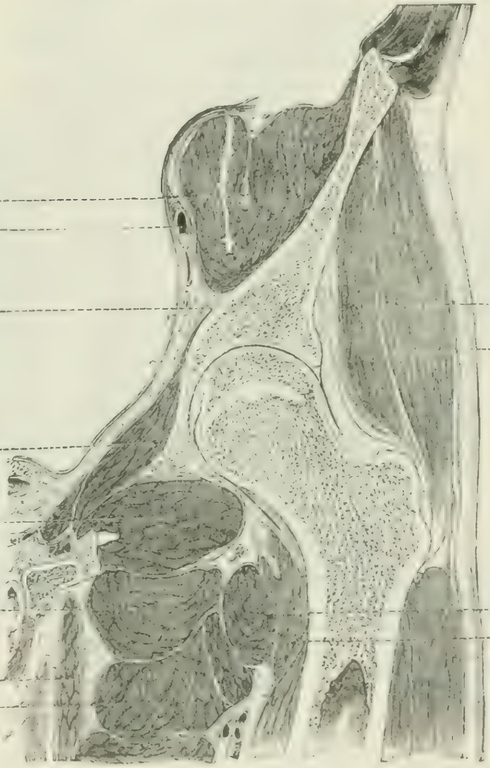
The head and shaft of the **femur** are well covered in, save in the emaciated. The head lies just below Poupart's ligament, under the ilio-psoas and a little to the outer side of the centre of that ligament. The outline of the condyles can be traced when the knee is flexed, and, on the outer side, a small portion of the shaft is accessible between the biceps and vastus externus.

Trochanter major.—This most valuable landmark is most prominent when the limb is rotated inwards or adducted; it lies at the bottom of a depression when the femur is everted. The only structures of importance between it and the skin are the expanded insertion of the gluteus maximus and the bursa beneath the muscle. This is often multilocular. The top of the great trochanter is about three-quarters of an inch (18 mm.) below the level of the femoral head, and, when the femur is extended, is a little below the centre of the hip-joint. This part of the bone is covered by the gluteus medius. The slightness of the prominence of the great trochanter in the living subject compared with that in the skeleton is explained by fig. 738, which shows how the descending gluteus medius and minimus fill up the space between the ilium and trochanter.

Nélaton's line.—This most useful guide is a line drawn from the anterior superior spine to the most prominent part of the tuberosity of the ischium. In normal limbs, the top of the great trochanter just touches this line. In dislocation, fractures of the neck, and in wasting of the neck, as in osteo-arthritis, the relation of the trochanter to Nélaton's line becomes altered.

The top of the great trochanter is a guide in Mr. Adams's operation for division

FIG. 738.—TRANSVERSE SECTION OF THE HIP-JOINT AND ITS RELATIONS. (One third.) (Braune.)

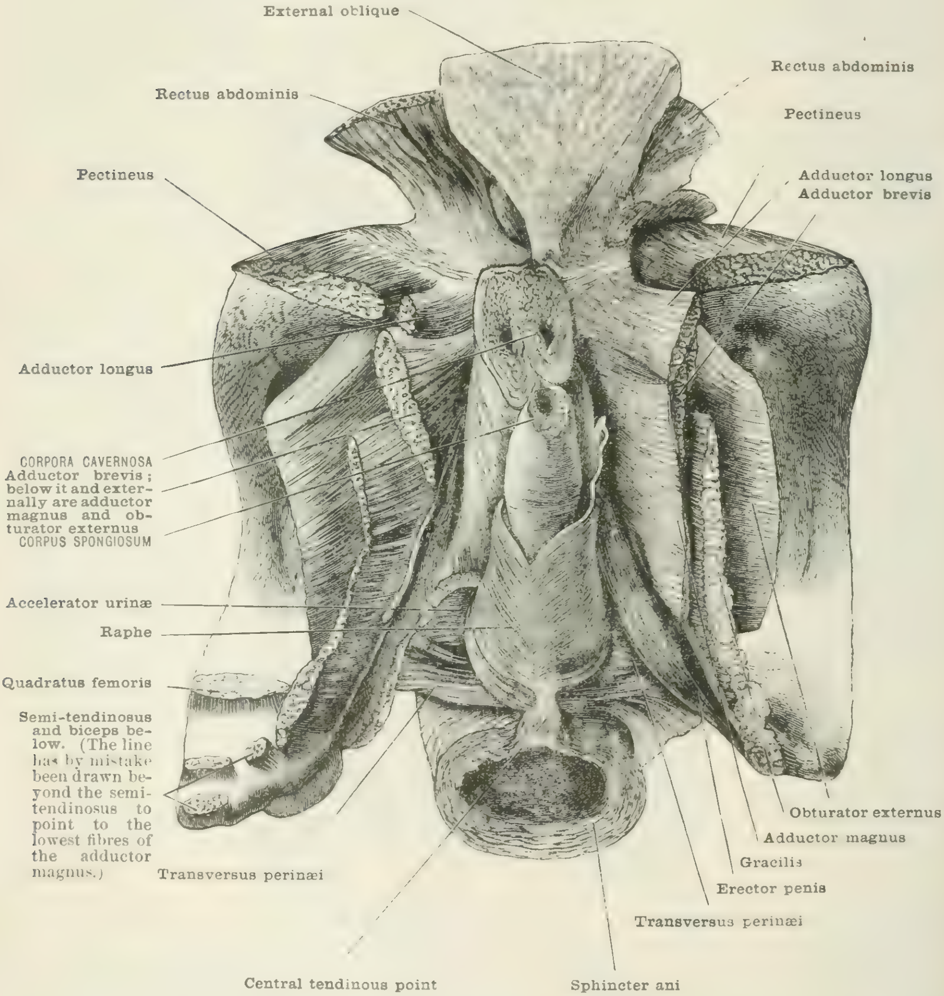

ANTERIOR CRURAL NERVE IN SUBSTANCE OF ILIACUS INTERNUS
External iliac artery
Gluteus minimus
Gluteus medius
Obturator internus
Adductor magnus
Obturator externus
Pectineus
Ilio-psoas
Adductor longus
Adductor brevis

of the neck of the femur, the puncture being made and the saw entered one inch (25 mm.) above and about one inch in front of this point.

Bryant's triangle.—Mr. Bryant makes use of the following in deciding the position of the great trochanter. The patient being flat on his back, (1) a line is dropped vertically on to the couch from the anterior superior spine; (2) from the top of the great trochanter a straight line in the long axis of the thigh is drawn to meet the first; (3) to complete the triangle, a line is drawn from the anterior superior spine to the top of the trochanter. This line is practically Nélaton's. The second line will be found diminished on the damaged or diseased side.

Muscular prominences.—The tensor vaginæ femoris (ilio-aponeurotic muscle) forms a prominence beginning just outside the sartorius and reaching downwards and somewhat backwards to the strong fascia lata, three to four inches (75 to 100 mm.) below the great trochanter. Below this point, as far as the outer tuberosity of the tibia, the strong ilio-tibial band can be felt. The sartorius, the chief landmark of the thigh, forming a boundary of Scarpa's triangle, Hunter's canal, and the popliteal space, can be readily brought into view by the patient's raising his limb. In the middle line the rectus muscle stands out in bold relief, with its tendon of insertion and the patella, when the leg is extended. On either side of this muscle is a furrow, and on either side, again, of this furrow the vasti become prominent. Between the vastus internus and adductor muscles is a depression indicating Hunter's canal. At the upper and inner third of the thigh, if the limb be abducted, the upper part of the adductor longus comes into strong relief. On the inner side below, above the knee-joint, the vertical fibres of the adductor magnus end in a powerful tendon coming down to the adductor tubercle (fig. 752). This replaces here the internal intermuscular septum, and the insertion of the tendon marks the level of the lower epiphysial line of the femur. At the outer and back part of the thigh the vastus externus is separated from the biceps by a groove which indicates the external intermuscular septum.

FIG. 739.—THE MUSCLES ATTACHED TO THE PUBES. (From a dissection in the Hunterian Museum.)


External oblique
Rectus abdominis
Rectus abdominis
Pectineus
Pectineus
Adductor longus
Adductor brevis
Adductor longus
CORPORA CAVERNOSA
Adductor brevis; below it and externally are adductor magnus and obturator externus
CORPUS SPONGIOSUM
Accelerator urinæ
Raphe
Quadratus femoris
Semi-tendinosus and biceps below. (The line has by mistake been drawn beyond the semi-tendinosus to point to the lowest fibres of the adductor magnus.)
Transversus perinæi
Obturator externus
Adductor magnus
Gracilis
Erector penis
Transversus perinæi
Central tendinous point
Sphincter ani

Poupart's ligament.—The abdomen is separated from the thigh by a fold, best marked in flexion—the inguinal furrow. In this, pressure detects the meeting of the aponeurosis of the external oblique and the fascia lata, i.e. Poupart's ligament, extending between the anterior superior spine of the ilium and the spine of the pubes. The line representing it should be drawn slightly convex downwards, owing to the attachment of the deep fascia. It forms the base of Scarpa's triangle; its inner attachment blends with the triangular Gimbernat's ligament. The parts passing under Poupart's ligament and their arrangement have been given elsewhere.

Scarpa's triangle (fig. 741).—Immediately below Poupart's ligament, a hollow is seen corresponding to this region, the outer and inner boundaries of which are brought into view when the limb is raised, the adductor longus especially when the limb is abducted, and the sartorius where the thigh is flexed and adducted and carried towards its fellow. Lying superficially in the base of the triangle, the lymphatic glands can be detected in a thin person (fig. 769). They lie in two groups —(*a*) One horizontal in a line with Poupart's ligament, and receiving lymph from the genitals, the lower part of the abdominal wall, and the inner aspect of the buttock; (*b*) a vertical set lying along the great vessels receiving lymph from the

FIG. 740.—DIAGRAM OF ARTERIES OF THIGH.

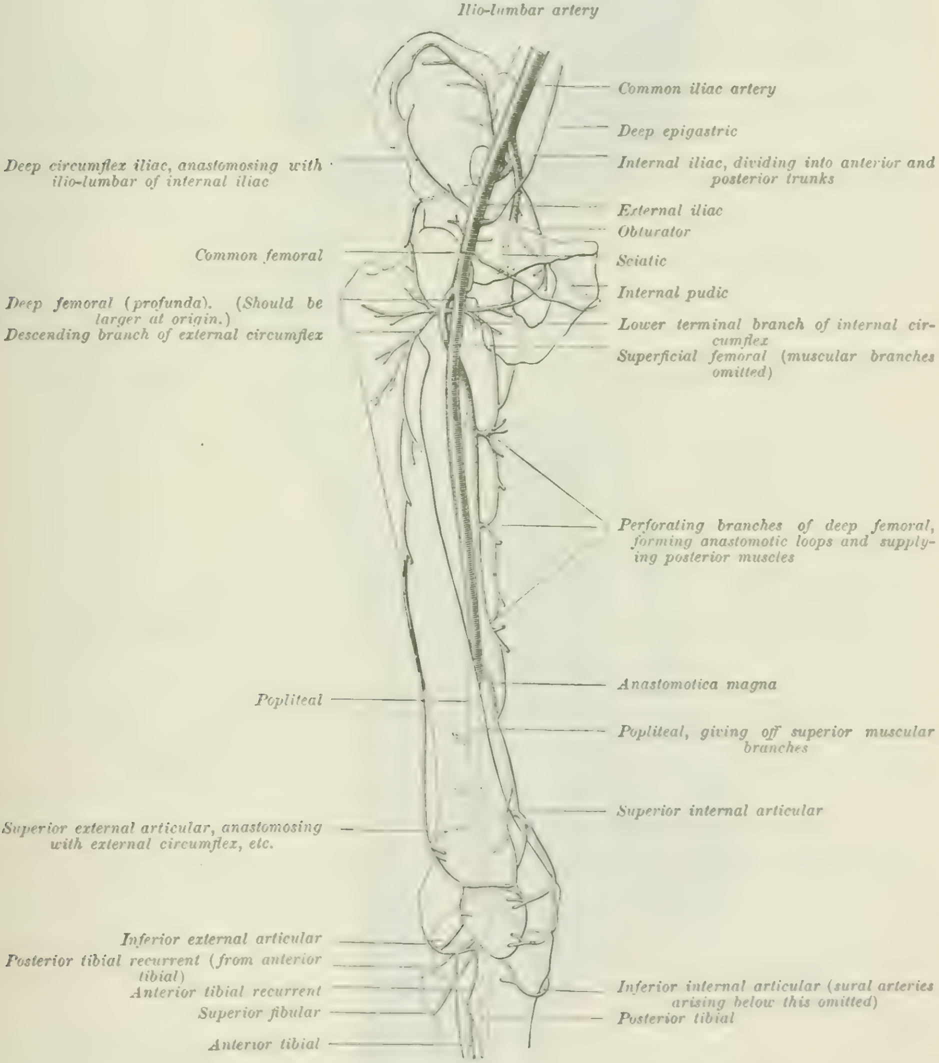

Ilio-lumbar artery
Common iliac artery
Deep epigastric
Deep circumflex iliac, anastomosing with ilio-lumbar of internal iliac
Internal iliac, dividing into anterior and posterior trunks
External iliac
Obturator
Common femoral
Sciatic
Internal pudic
Deep femoral (profunda). (Should be larger at origin.)
Descending branch of external circumflex
Lower terminal branch of internal circumflex
Superficial femoral (muscular branches omitted)
Perforating branches of deep femoral, forming anastomotic loops and supplying posterior muscles
Anastomotica magna
Popliteal
Popliteal, giving off superior muscular branches
Superior internal articular
Superior external articular, anastomosing with external circumflex, etc.
Inferior external articular
Posterior tibial recurrent (from anterior tibial)
Anterior tibial recurrent
Superior fibular
Inferior internal articular (sural arteries arising below this omitted)
Posterior tibial
Anterior tibial

FIG. 741.—SECTION OF THE RIGHT THIGH AT THE APEX OF SCARPA'S TRIANGLE. (Heath.)

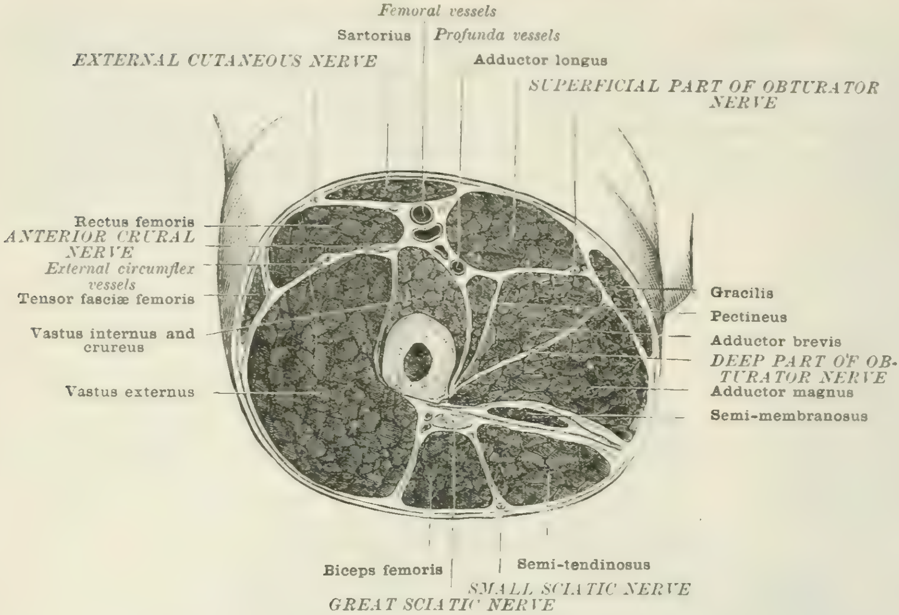
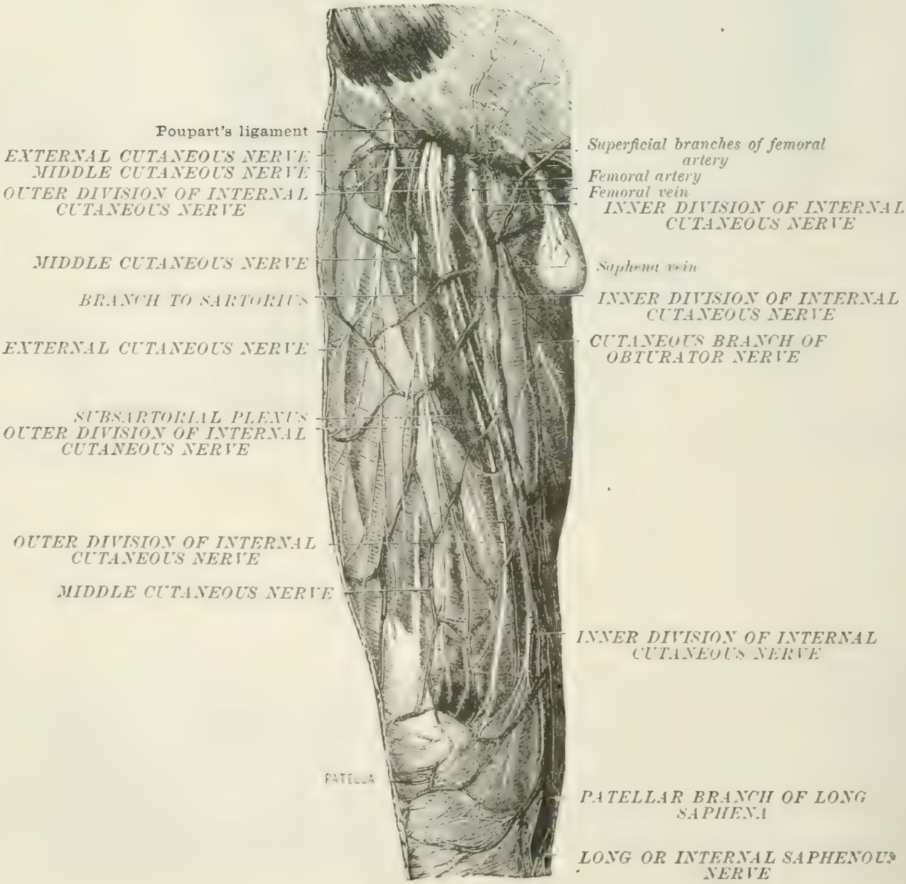

Femoral vessels
Sartorius
Profunda vessels
EXTERNAL CUTANEOUS NERVE
Adductor longus
SUPERFICIAL PART OF OBTURATOR NERVE
Rectus femoris
ANTERIOR CRURAL NERVE
External circumflex vessels
Tensor fasciæ femoris
Vastus internus and crureus
Vastus externus
Gracilis
Pectineus
Adductor brevis
DEEP PART OF OBTURATOR NERVE
Adductor magnus
Semi-membranosus
Biceps femoris
Semi-tendinosus
SMALL SCIATIC NERVE
GREAT SCIATIC NERVE

FIG. 742.—SUPERFICIAL DISSECTION OF THE FRONT OF THE THIGH. (Hirschfeld and Leveillé.)

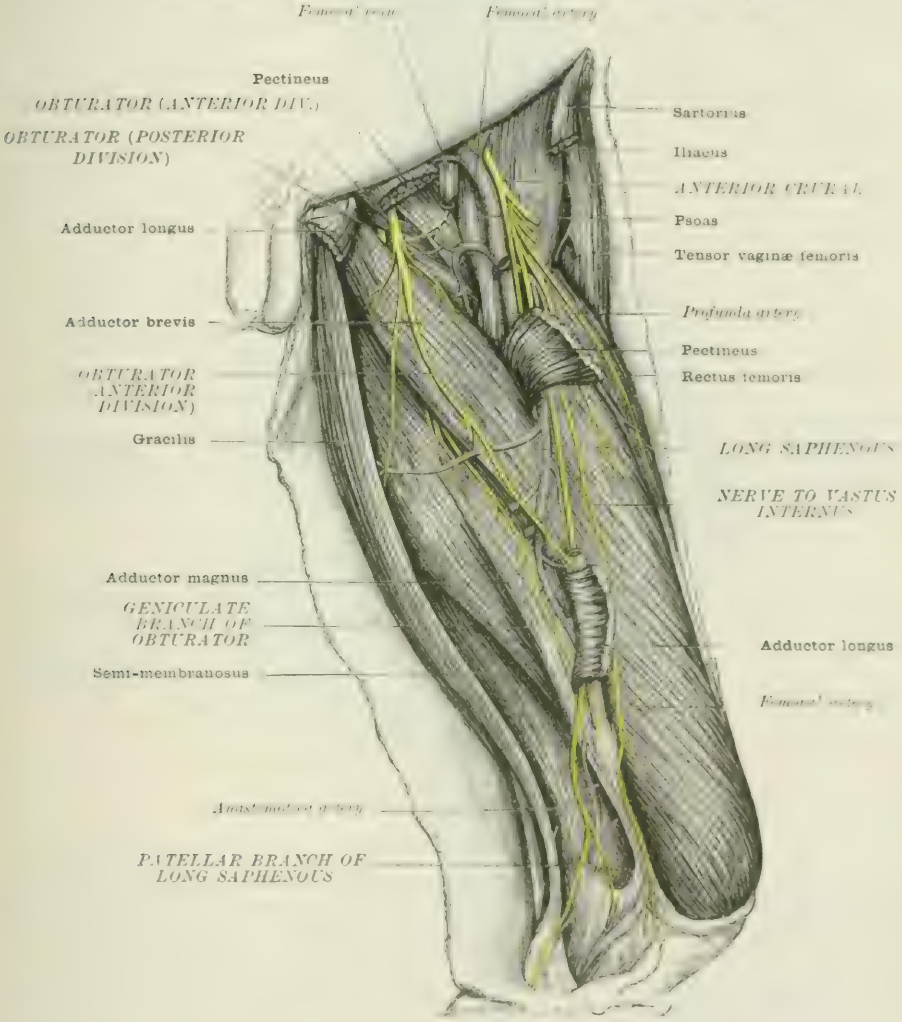

Poupart's ligament
EXTERNAL CUTANEOUS NERVE
MIDDLE CUTANEOUS NERVE
OUTER DIVISION OF INTERNAL CUTANEOUS NERVE
MIDDLE CUTANEOUS NERVE
BRANCH TO SARTORIUS
EXTERNAL CUTANEOUS NERVE
SUBSARTORIAL PLEXUS
OUTER DIVISION OF INTERNAL CUTANEOUS NERVE
OUTER DIVISION OF INTERNAL CUTANEOUS NERVE
MIDDLE CUTANEOUS NERVE
PATELLA
Superficial branches of femoral artery
Femoral artery
Femoral vein
INNER DIVISION OF INTERNAL CUTANEOUS NERVE
Saphena vein
INNER DIVISION OF INTERNAL CUTANEOUS NERVE
CUTANEOUS BRANCH OF OBTURATOR NERVE
INNER DIVISION OF INTERNAL CUTANEOUS NERVE
PATELLAR BRANCH OF LONG SAPHENA
LONG OR INTERNAL SAPHENOUS NERVE

limb. According to Mr. Treves, a few of the superficial genital lymphatics, and all those from the perinæum, go into the vertical group.

Saphenous opening.—The depression corresponding to this is placed just below Gimbernat's ligament, with which its upper extremity blends. Its centre is about an inch and a half (37 mm.) below and also external to a line dropped vertically from the pubic spine. This and the other structures concerned in femoral hernia are fully described under this section (*vide supra*, page 1138).

Line of femoral artery.—A line drawn from the mid-point between the anterior superior spine and the symphysis pubis to the adductor tubercle will correspond with the course of this vessel. The sartorius usually crosses it, three to four inches (100 mm.) below Poupart's ligament. The profunda artery arises an inch and a half to two inches below Poupart's ligament. Therefore the incision for tying the femoral in Scarpa's triangle should be about three inches long, in the line of the artery, and begin about three inches below Poupart's ligament, and run over the apex of the triangle. The vein lies, below Poupart's ligament, immediately to the inner side of the artery. From this point the vein gets on to a somewhat deeper plane, though still very close to the artery, and gradually inclining back-

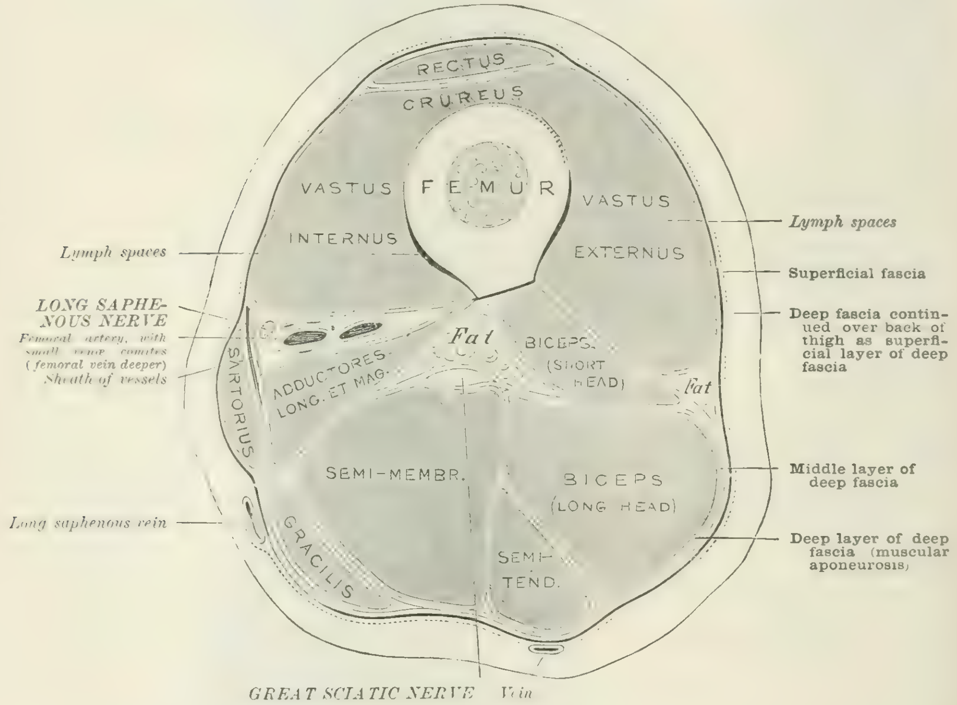
FIG. 743.—ANTERIOR CRURAL AND OBTURATOR NERVES. (Ellis.)


Femoral vein
Femoral artery
Pectineus
OBTURATOR (ANTERIOR DIV.)
OBTURATOR (POSTERIOR DIVISION)
Adductor longus
Adductor brevis
OBTURATOR ANTERIOR DIVISION)
Gracilis
Adductor magnus
GENICULATE BRANCH OF OBTURATOR
Semi-membranosus
Anastomotica artery
PATELLAR BRANCH OF LONG SAPHENOUS
Sartorius
Iliacus
ANTERIOR CRURAL
Psoas
Tensor vaginæ femoris
Profunda artery
Pectineus
Rectus femoris
LONG SAPHENOUS
NERVE TO VASTUS INTERNUS
Adductor longus
Femoral artery

wards, lies behind its companion at the apex of the triangle, and below lies somewhat to its outer side.

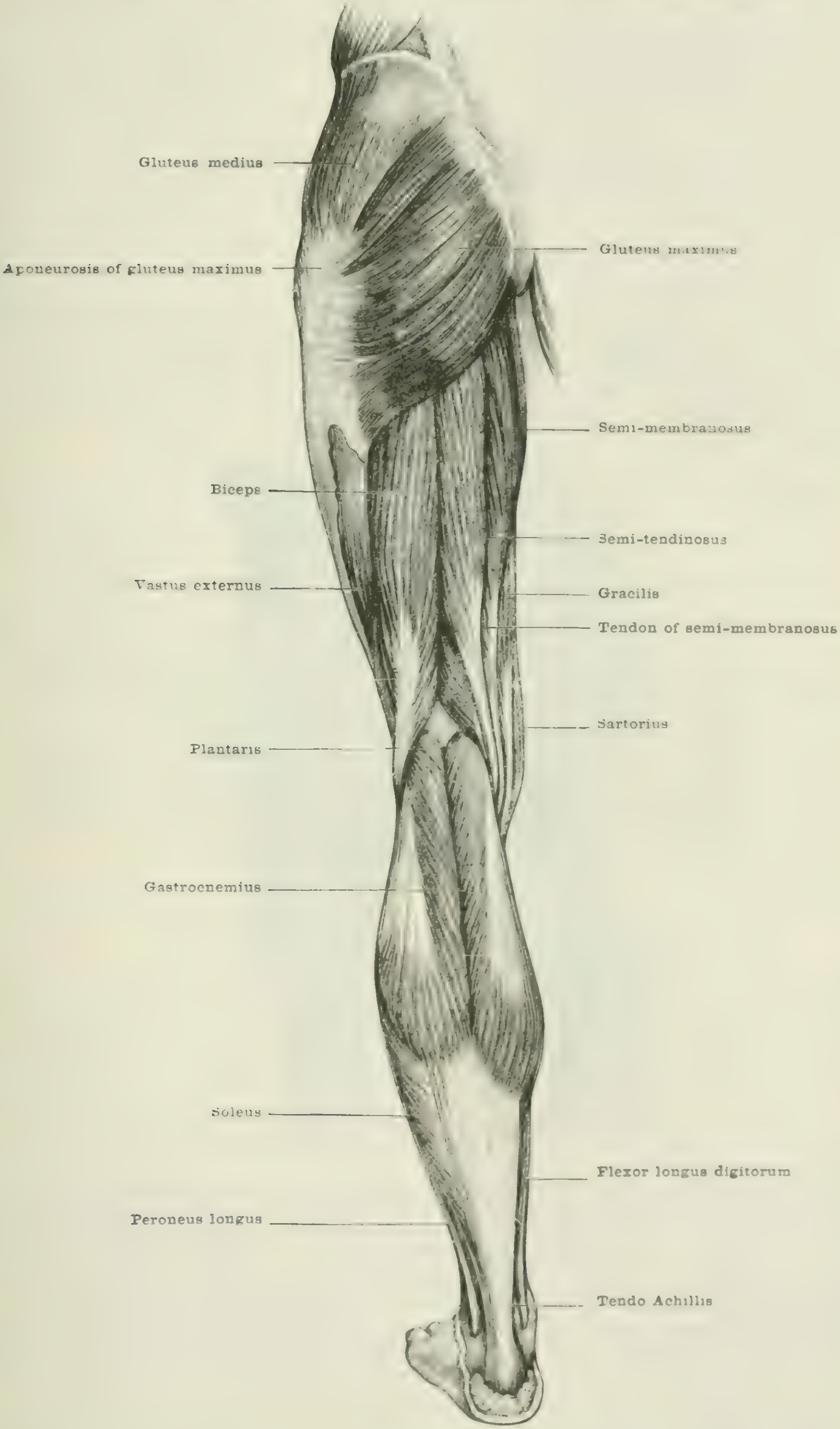
From the apex of Scarpa's triangle a depression runs down along the inner aspect of the thigh, corresponding to the groove already mentioned (page 1175) between the vastus internus and the adductors. Along this groove lies the sartorius, and beneath it **Hunter's canal.** The vein has here got somewhat to the outer side. The long saphenous nerve lies also in the canal, but not in the sheath. The above-mentioned space terminates at about the junction of the middle and lower thirds of the thigh, in the opening in the adductor magnus by which the artery enters the upper and inner part of the popliteal space. The long saphenous, the largest branch of the anterior crural nerve, having crossed the femoral vessels from without inwards, accompanies them as far as the opening in the adductor magnus. Here it perforates the aponeurotic roof, and is prolonged under the sartorius, accompanied by the superficial part of the anastomotic artery, to perforate the fascia lata between the sartorius and gracilis, and run with the long saphena vein at the upper and inner part of the leg.

Fig. 744—Section of Thigh through upper part of Hunter's Canal. (W. A.)


RECTUS
CRUREUS
VASTUS
INTERNUS
FEMUR
VASTUS
EXTERNUS
Lymph spaces
Lymph spaces
Superficial fascia
LONG SAPHENOUS NERVE
Femoral artery, with small venæ comites (femoral vein deeper)
Sheath of vessels
Deep fascia continued over back of thigh as superficial layer of deep fascia
Fat
BICEPS (SHORT HEAD)
Fat
SARTORIUS
ADDUCTORES LONG. ET MAG.
SEMI-MEMBR.
BICEPS (LONG HEAD)
Middle layer of deep fascia
Long saphenous vein
GRACILIS
SEMI-TEND.
Deep layer of deep fascia (muscular aponeurosis)
GREAT SCIATIC NERVE
Vein

Pressure may be applied to the femoral artery—(1) Immediately below Poupart's ligament: it should here be directed backwards so as to compress the vessel against the brim of the pelvis and the capsule of the hip-joint; (2) at the apex of Scarpa's triangle, the pressure here being directed outwards and a little backwards, so as to command the vessel against the bone; (3) in Hunter's canal the pressure should be directed outwards with the same object. Care must be taken, especially above, to avoid the vein, which lies very close to the artery, and also the anterior crural nerve, which enters the thigh about half an inch (12 mm.) outside the artery, and at once breaks up into its branches, superficial and deep.

FIG. 745.—SUPERFICIAL MUSCLES OF THE BACK OF THE THIGH AND LEG.


Gluteus medius
Aponeurosis of gluteus maximus
Gluteus maximus
Semi-membranosus
Biceps
Semi-tendinosus
Vastus externus
Gracilis
Tendon of semi-membranosus
Sartorius
Plantaris
Gastrocnemius
Soleus
Flexor longus digitorum
Peroneus longus
Tendo Achillis

THE BUTTOCKS

Bony landmarks.—The finger readily traces the whole outline of the iliac crest. Behind, it terminates in the posterior superior spine, which corresponds in level to the second sacral spine and the centre of the sacro-iliac joint (Holden).

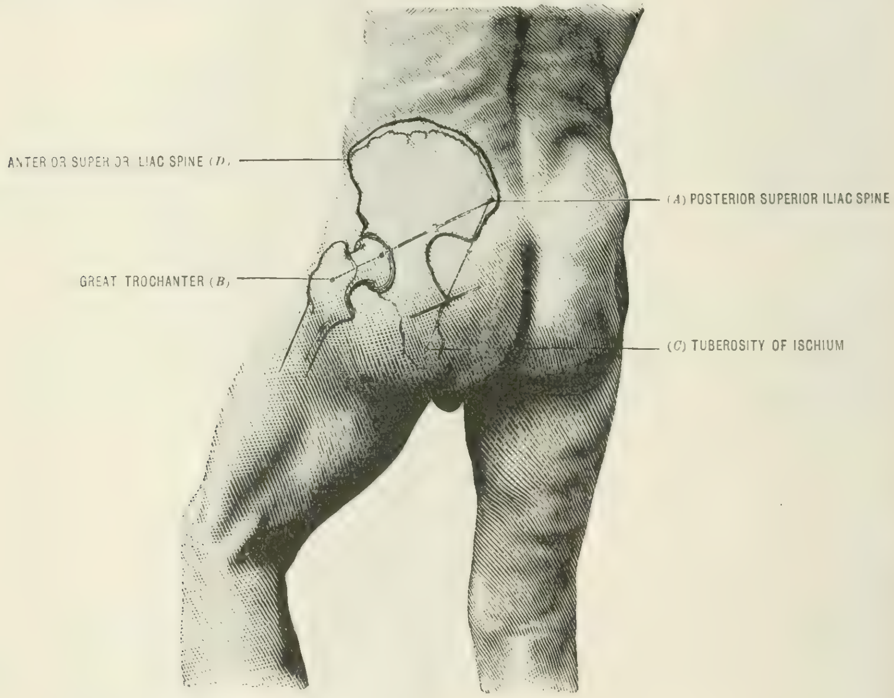
The third sacral spine marks the lowest limit of the spinal membranes and the cerebro-spinal fluid; it also corresponds to the upper border of the great sacro-sciatic notch.

The first piece of the coccyx corresponds to the spine of the ischium (Windle). Its apex is in the furrow just behind the last piece of the rectum.

Fig. 746.—Position and Direction of the Superficial Incisions which must be made in order to reach the Gluteal, Sciatic, and Pudic Arteries.

A.B. Ilio-trochanteric line divided into thirds, and corresponding in direction with the line of the gluteus maximus. The incision to reach the gluteus maximus is indicated by the dark part of the line. Its centre is at the position of the upper and middle thirds of the ilio-trochanteric line, and corresponds with the point of emergence of the artery from the great sciatic notch.

A.C. Ilio-ischiatic line. The incision to reach the sciatic or pudic artery is indicated by the lower dark line. This is also to be made in the direction of the fibre of the gluteus maximus. Its centre corresponds to the position of the lower and middle thirds of the ilio-ischiatic line.


ANTERIOR SUPERIOR ILIAC SPINE (*D*)
GREAT TROCHANTER (*B*)
(*A*) POSTERIOR SUPERIOR ILIAC SPINE
(*C*) TUBEROSITY OF ISCHIUM

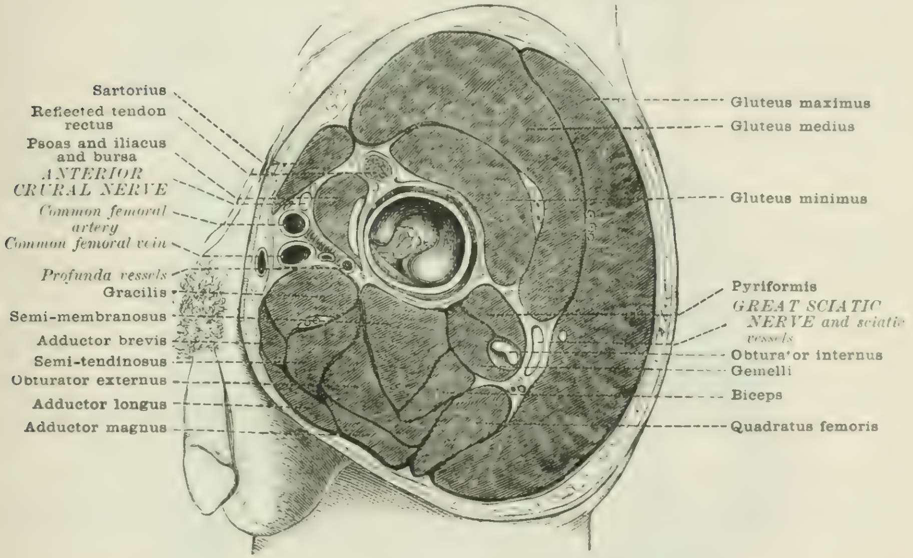
The tuberosities of the ischium are readily felt by deep pressure on either side of the anus. In the erect position they are covered by the lower margin of the gluteus maximus. In sitting they are protected by tough skin, fasciæ, with coarse fibrous fat, and often by a bursa known, according to the patients in whom it becomes enlarged, as 'weaver's, coachman's, lighterman's, drayman's' bursa.

Gluteus maximus.—The 'fold of the buttock' neither corresponds accurately to, nor is caused by, the lower margin of this muscle. It is really due to creasing of the skin adherent here to the coarsely fibro-fatty tissue over the tuber ischii during extension. But in early hip disease, in which flexion of the joint is almost unvaryingly present, both the fold and the gluteus maximus disappear with characteristic rapidity. The prominence of the buttock is mainly due to the gluteus maximus, especially behind and below, and in less degree to the other two glutei in front. Under the lower edge of the gluteus maximus the edge of the great sacro-sciatic ligament can be felt on deep pressure.

Nerves and vessels.—The following **superficial nerves** can be marked in over the buttock (fig. 770). Behind the great trochanter, branches of the external cutaneous. Coming down over the crest, the lateral cutaneous branch of the last dorsal (about in a line with the great trochanter), and behind this the lateral branch of the ilio-hypogastric. Two or three offsets of the posterior primary branches of the lumbar nerves cross the hinder part of the iliac crest at the outer margin of the erector spinæ. Two or three twigs from the posterior divisions of the sacral nerves pierce the gluteus maximus close to the coccyx and sacrum, and ramify outwards. Finally, over the lower border of the gluteus maximus turn upwards branches of the small sciatic and inferior pudendal and fourth sacral nerves.

Great sciatic nerve (figs. 748, 749).—The point of emergence below the gluteus maximus and the track of this nerve will be given by a line drawn from a spot a little internal to the middle of the space between the great trochanter and the tuber ischii to the lower part of the back of the thigh. The inferior pudendal perforates the deep fascia about an inch (25 mm.) in front of the tuber ischii, and turns forwards to supply the genitals.

FIG. 747.—SECTION THROUGH THE HIP AND GLUTEAL REGION. (One third.)


Sartorius
Reflected tendon rectus
Psoas and iliacus and bursa
ANTERIOR CRURAL NERVE
Common femoral artery
Common femoral vein
Profunda vessels
Gracilis
Semi-membranosus
Adductor brevis
Semi-tendinosus
Obturator externus
Adductor longus
Adductor magnus
Gluteus maximus
Gluteus medius
Gluteus minimus
Pyriformis
GREAT SCIATIC NERVE and sciatic vessels
Obturator internus
Gemelli
Biceps
Quadratus femoris

Gluteal artery.—If a line be drawn from the posterior superior spine to the apex of the great trochanter, the limb being slightly flexed and rotated inwards, the point of emergence of the artery from the upper part of the great sacro-sciatic notch will correspond with the junction of the upper and middle third of this line (fig. 746) (MacCormac). The gluteal nerve emerges immediately below the artery, and sends branches with the deeper portion.

Sciatic and pudic arteries.—The limb being rotated inwards, a line is drawn from the posterior superior spine to the outer part of the tuber ischii. The point of exit of the above arteries will correspond to the junction of the middle and lower thirds of this line (MacCormac).

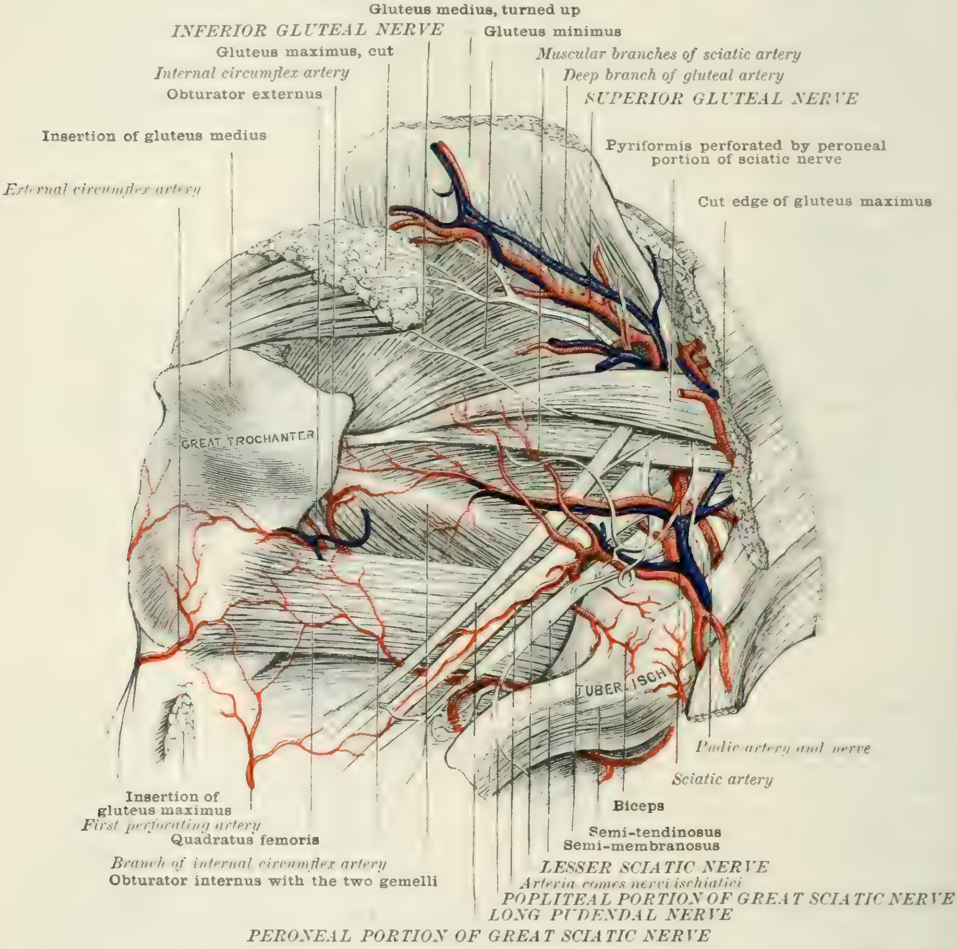
THE KNEE

Bony landmarks.—The patella, the condyles, the tuberosities of the tibia, the tubercle of the tibia, the head of the fibula.

FIG. 748.—THE GLUTEAL REGION, WITH THE GLUTEAL, SCIATIC, AND PUDIC ARTERIES.

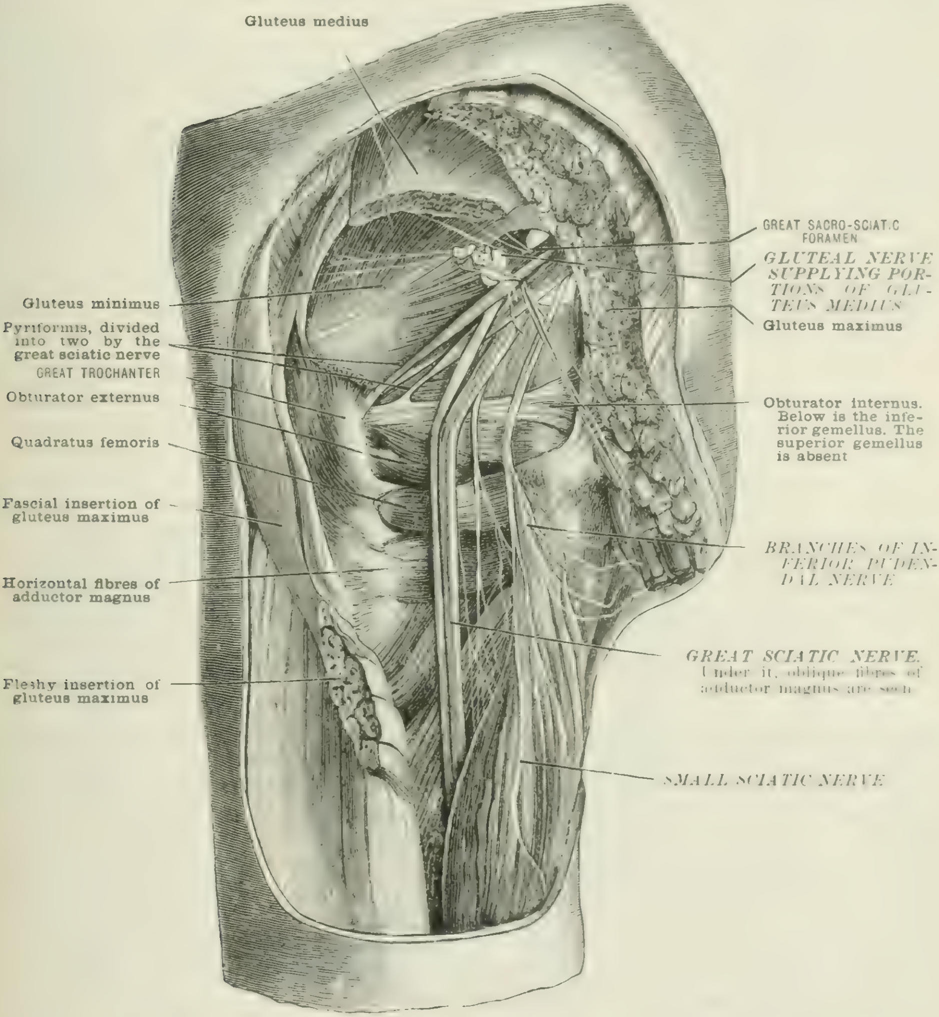
(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)

The inferior gluteal branch of the sciatic artery has been drawn inwards over the tuber ischii with the reflected origin of the gluteus maximus muscle.


Gluteus medius, turned up
INFERIOR GLUTEAL NERVE
Gluteus minimus
Gluteus maximus, cut
Muscular branches of sciatic artery
Internal circumflex artery
Deep branch of gluteal artery
Obturator externus
SUPERIOR GLUTEAL NERVE
Insertion of gluteus medius
Pyriformis perforated by peroneal portion of sciatic nerve
External circumflex artery
Cut edge of gluteus maximus
GREAT TROCHANTER
TUBER ISCHI
Pudic artery and nerve
Sciatic artery
Biceps
Insertion of gluteus maximus
First perforating artery
Quadratus femoris
Semi-tendinosus
Semi-membranosus
Branch of internal circumflex artery
LESSER SCIATIC NERVE
Obturator internus with the two gemelli
Arteria comes nervi ischiatici
POPLITEAL PORTION OF GREAT SCIATIC NERVE
LONG PUDENDAL NERVE
PERONEAL PORTION OF GREAT SCIATIC NERVE

The patella.—The limb being supported in the straight position, and the extensor muscles relaxed, the numerous longitudinal striæ or sulci on the anterior surface of this bone can be detected. In these are embedded tendinous bundles of the rectus, so as to give firmer leverage. The fact that these fibres, thus tied down, are liable to fold in between the ends of the bone after fracture, is a ready explanation of the difficulty of ensuring bony union here (Macewen). The patella is separated from the tibia by a pad of fat and a deep bursa, save at its insertion. It has the following relation to the femur in different positions:—(1) In **extension,** the patella rises over the condyles, and in full extension only the lower third of its articular surface rests upon that of the condyles; its upper two-thirds lies upon the bed of fat which covers the lower and front part of the femur. (2) In extreme **flexion,** as the prominent anterior surface of the condyles affords leverage to the quadriceps, the patella needs to project very little; thus, only its upper third is in contact with the femur, its lower two-thirds now resting on the pad of fat between it and the tibia. (3) In **semiflexion** the middle third of the patella rests upon the most prominent part of the condyles (Humphry). While the bone now affords the greatest amount of leverage to the quadriceps, it is also submitted to the greatest amount of strain from this muscle, which is acting almost at a right angle to the long axis of the patella. This position may therefore be called 'the area of danger,' as, in a sudden and violent contraction, the patella may be snapped across by muscular action, aided by the resistance given by the condyles, in the same way as a stick is snapped across the knee. Below its articular surface for the femur it is separated from the tibia by a pad of fat and a deep bursa, save at the apex to which the ligamentum patellæ is attached. When the knee-joint is bent, the trochlear surface of the former can be made out, with some difficulty, underneath the quadriceps expansion. The upper and outer angle of this surface forms a useful landmark (Godlee), as a line drawn from it to the adductor tubercle marks the level of the lower epiphysis of the femur.

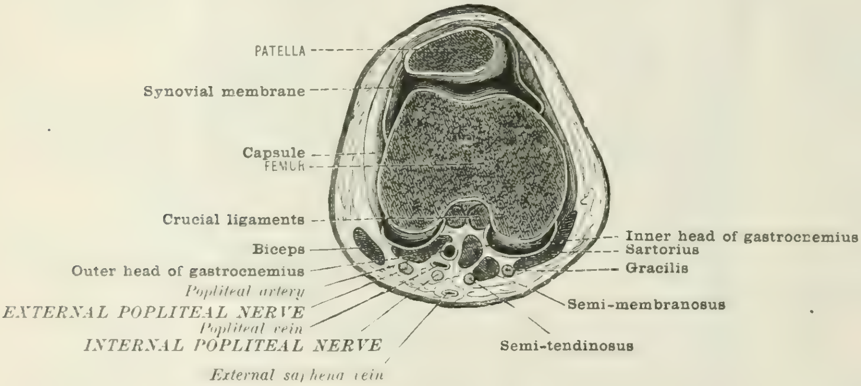
FIG. 749.—DEEP DISSECTION OF THE GLUTEAL REGION. (From a preparation in the Hunterian Museum.)


Gluteus medius
GREAT SACRO-SCIATIC FORAMEN
GLUTEAL NERVE SUPPLYING PORTIONS OF GLUTEUS MEDIUS
Gluteus minimus
Gluteus maximus
Pyriformis, divided into two by the great sciatic nerve
GREAT TROCHANTER
Obturator externus
Obturator internus. Below is the inferior gemellus. The superior gemellus is absent
Quadratus femoris
Fascial insertion of gluteus maximus
BRANCHES OF INFERIOR PUDENDAL NERVE
Horizontal fibres of adductor magnus
GREAT SCIATIC NERVE. Under it, oblique fibres of adductor magnus are seen
Fleshy insertion of gluteus maximus
SMALL SCIATIC NERVE

Dislocation of the patella.—The following anatomical facts account for this taking place much more frequently outwards:—(1) The inner edge of the patella is more prominent, and thus more exposed to injury; it is also well supported, as is seen when, the parts being relaxed, the fingers are insinuated beneath each border. (2) The pull of the extensor upon the patella, ligamentum patellæ, and tibia is somewhat outwards, as the tibia is directed a little outwards to the femur, to meet the inward direction of this bone; the femora being directed inwards here, to bring the knee-joints nearer the centre of gravity, and, so, counterbalance their wide separation above at the pelvis. The outward pull of the quadriceps upon the patella is, in all normal action of the muscle, counteracted by the space taken in the trochlear surface by the external condyle, this being wider and creeping up higher, and having a more prominent and thus protective lip. In violent contraction, however, these counteracting points may be overcome.

The condyles and tuberosities.—It should be noted that on the inner side the prominence of the internal condyle is well marked, and that of the tibial tuberosity is less so, while on the outer side this condition is reversed. Descending to the outer tuberosity, the ilio-tibial band of the fascia lata can be traced. The more distinct outer tuberosity is a good landmark for opening the joint in amputation and excision. It also indicates the lower level of the synovial membrane of the knee-joint. Farther back is the biceps and long external lateral ligament. The gap on the inner side between condyle and tuberosity is the place for feeling for a displaced internal fibro-cartilage in 'internal derangement' of the knee. On each condyle, posteriorly, in a thin subject can be felt its tubercle, which gives attachment to the lateral ligament. Owing to their being placed behind the centre of the bone these ligaments become tight in extension. On the upper part of the internal condyle the adductor tubercle and the vertical tendon of the adductor magnus can be felt during flexion. This bony point is a guide to the lower epiphysis of the femur, one of the latest to join, uniting with the shaft about the twenty-first year. Here the exostoses in adolescents arise. The inner aspect of this condyle faces practically in the same direction as the head of the femur.

Fig. 750.—Horizontal Section of the Knee-joint. (One-half.)



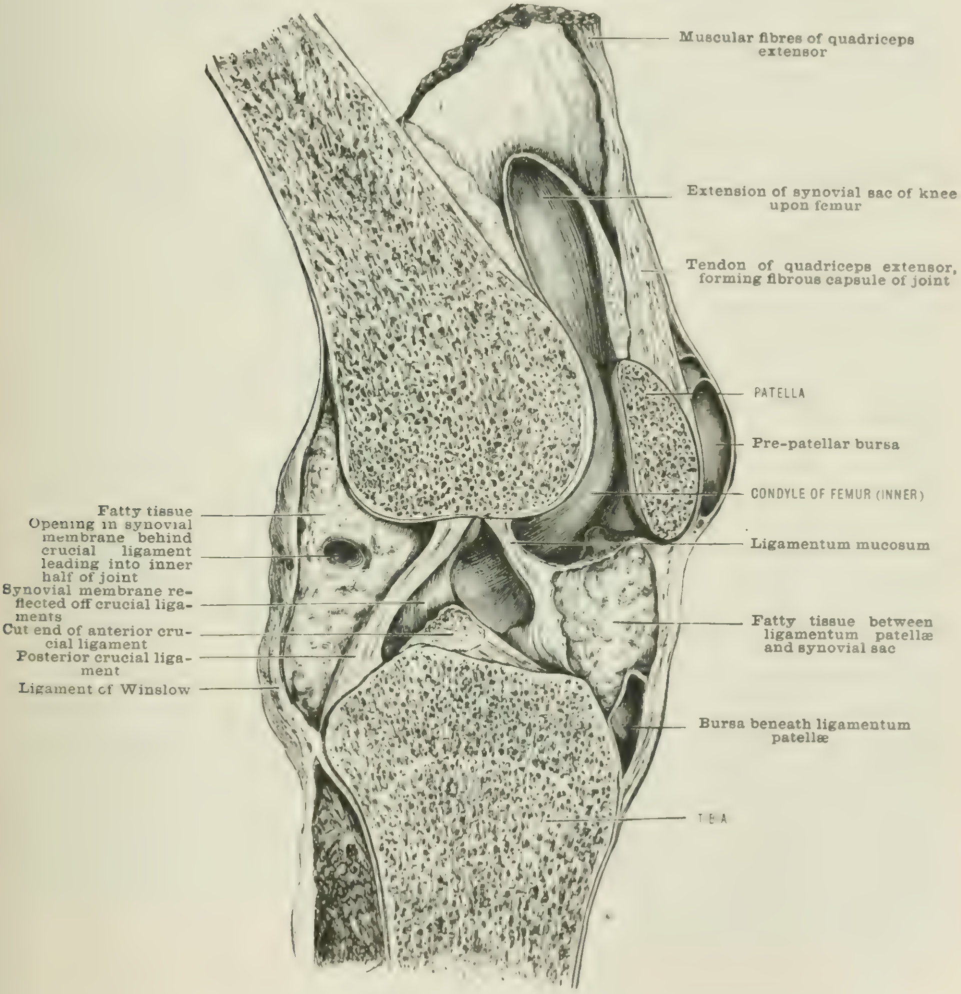
Ligamentum patellæ and tubercle of tibia.—These, in a well-formed leg, should, with the centre of the ankle-joint, be all in the same straight line, a useful point in the adjustment of fractures (Holden). Behind the upper half of the ligament is the synovial membrane of the knee-joint; below, the lower is separated from the tibia by a deep bursa. In connection with all the posterior surface is fat, which serves as a useful packing in the different movements of flexion and extension. The tubercle of the tibia is on a level with the head of the fibula.

Prepatellar bursa.—This usually protects the patella and upper part of the ligamentum patellæ. It is liable to be enlarged in those who habitually kneel much. Its close connection with the patella and, at the sides, with the joint itself is to be remembered in inflammations of the bursa. Usually, two processes of fascia lata, passing off from the sides of the patella upwards to the thigh and downwards to the leg, serve to conduct inflammation away from the joint.

FIG. 751.—VERTICAL SECTION OF THE KNEE-JOINT IN THE ANTERO-POSTERIOR DIRECTION.

(The synovial bursa usually present above the upper synovial *cul de-sac* is not shown.)

(The bones are somewhat drawn apart.)


Muscular fibres of quadriceps extensor
Extension of synovial sac of knee upon femur
Tendon of quadriceps extensor, forming fibrous capsule of joint
PATELLA
Pre-patellar bursa
CONDYLE OF FEMUR (INNER)
Ligamentum mucosum
Fatty tissue between ligamentum patellæ and synovial sac
Bursa beneath ligamentum patellæ
TIBIA
Fatty tissue
Opening in synovial membrane behind crucial ligament leading into inner half of joint
Synovial membrane reflected off crucial ligaments
Cut end of anterior crucial ligament
Posterior crucial ligament
Ligament of Winslow

Synovial membrane (fig. 751).—To trace this, the largest of the synovial membranes, the finger would start from the top of the patella, where it forms a short *cul-de-sac* between the quadriceps extensor and the front of the femur, this process reaching about an inch (25 mm.) above the trochlear surface of the femur. At its highest point this *cul-de-sac* communicates with another synovial bursa-like sac lying between the quadriceps and front of the femur. Thus, synovial membrane will usually be met with two and a half inches (62 mm.) above the trochlear surface or the upper border of the patella when the limb is extended. Flexing the joint draws the membrane down very slightly. During extension, the above pouch is supported by the subcrureus. At the sides the synovial membrane extends up under the vasti for about three inches (75 mm.) on the inner and rather less on the outer side. Traced downwards, the membrane lines the capsule, lateral and posterior ligaments. It passes over the greater portion of the crucial ligaments, but the posterior surface of the posterior crucial, which is connected by means of fibro-areolar tissue to the front of the ligamentum posticum, and the lower portions of both crucial ligaments, where they are united together, of course cannot receive a complete covering from the membrane' (Morris). From the above ligaments the membrane is conducted, lining the lower part of the capsule and other ligaments, to the semi-lunar cartilages, first over their upper surfaces to their free borders, and then along their under surfaces to the tibia. Between the outer of these and the upper and back part of the tibia is a prolongation of the synovial membrane to facilitate the play of the popliteus tendon. Special folds, with their packing of fat, the ligamenta alaria and mucosa, pass between the femur and patella.

The following **bursæ about the knee-joint** must be remembered. Some, it will be seen, are much more constant than others:—

A. **In front.**—(1) One between the patella and skin, the bursa prepatellaris (fig. 751); (2) a deeper one between the ligamentum patellæ and the upper part of the tibia; (3) between the skin and the lower part of the tubercle of the tibia. This is not constant.

B. **On the inner side.**—(1) One between the inner head of the gastrocnemius and inner condyle, often extending between the above muscle and the semi-membranosus. This is the largest of the bursæ about the knee-joint, and, after adult life, usually communicates with the knee-joint; (2) one superficial to the internal lateral ligament, between it and the tendon of the sartorius, gracilis, and semitendinosus; (3) one beneath the ligament, between it and the tendon of the semimembranosus; (4) one between the inner tuberosity of the tibia and the semi-membranosus; (5) one between the semi-membranosus and semi-tendinosus. Of the above bursæ, the first two alone are constant. The second and third are often one bursa prolonged.

C. **On the outer side.**—(1) One between the outer head of the gastrocnemius and the condyle; (2) one superficial to the external lateral ligament between it and the biceps tendon; (3) one under the ligament between it and the popliteus tendon; (4) one between the popliteus tendon and the outer condyle of the femur. This is usually a diverticulum from the synovial membrane.

The following explanations may be given of an inflamed knee-joint usually taking the flexed position: (1) By experimental injections, Braune found that the capacity of the synovial sac reaches its maximum with a definite degree of flexion, i.e. at an angle of twenty-five degrees. (2) As the same nerves supply the synovial membrane and the muscles which act upon the joint, the flexors being more powerful than the extensors, will help to explain the flexed position (Hilton).

Anastomoses around the front and sides of the knee-joint.—The most important of these take the form of **three transverse arches.** (1) The **highest** passes through the quadriceps fibres just above the upper edge of the patella. It is formed by a branch from the deep division of the anastomotica and one from the superior external articular. The middle and lowest arches lie under the ligamentum patellæ. (2) The **middle arch,** formed by branches from the anastomotica and superior internal articular on the inner side, and the inferior external articular, on the outer, runs in the fatty tissue close to the apex of the patella. (3) The **lowest arch** lies on the tibia just above its tubercle, and results from the anastomosis of the recurrent tibial and the inferior internal articular. Six arteries thus take place in this series of anastomoses.

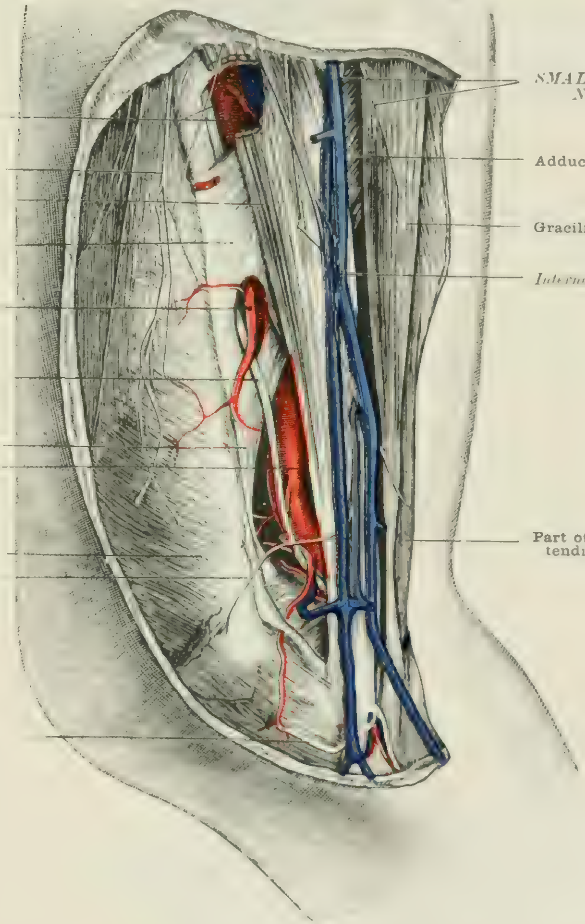
POPLITEAL SPACE

In flexion, the **hollow of this space** appears; in extension it is obliterated and its boundaries are ill-defined, the only one now to be made out being the semitendinosus and the biceps.

Popliteal tendons.—When the knee is a little bent, and the foot rests on the ground, the following can be made out: At the outer side, behind the ilio-tibial band, and descending to the head of the fibula, is the tendon of the biceps. Parallel and close to its inner border, the external popliteal nerve descends, as a rounded cord, to cross the neck of the fibula and enter the peroneus longus. In tenotomy of the biceps, the knife should be introduced between the nerve and the tendon, and made to cut from within outwards, and thus away from the nerve. On the inner side the tendons are thus arranged: Nearest to the middle of the popliteal space is the long and more slender tendon of the semi-tendinosus; next, the thicker tendon of the semi-membranosus; this and the gracilis, which comes next, appear as one tendon, but by a little manipulation the finger can be made to sink into the interval between the semi-membranosus, with its thick rounded border externally and the gracilis internally. The sartorius can easily be thrown into relief on the inner side of the joint by telling the patient to cross one leg.

FIG. 752.—SIDE VIEW OF THE POPLITEAL ARTERY.

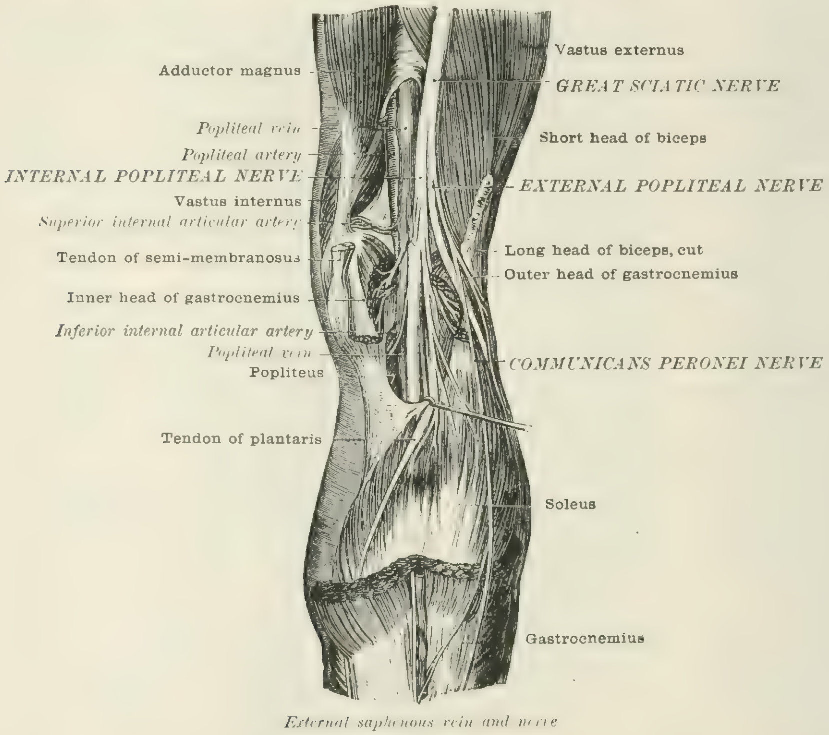
(From a dissection in the Hunterian Museum.)


Femoral artery and vein
BRANCHES OF THE INTERNAL CUTANEOUS NERVE
Sartorius
Aponeurotic covering of Hunter's canal
Anastomotica magna artery
LONG SAPHENOUS NERVE
Vertical fibres of the adductor magnus
Popliteal artery
Vastus internus
Cut edge of fascia lata
BRANCH OF SAPHENOUS NERVE TO PATELLAR PLEXUS
SMALL SCIATIC NERVE
Adductor magnus
Gracilis
Internal saphenous vein
Part of semi-tendinosus

Popliteal vessels.—The **artery** traverses this space from above downwards, appearing beneath the semi-membranosus, a little to the inner side of the middle line, and then passing down in the centre of the space to the interval between the gastrocnemii. Its course corresponds with a line drawn from the inner side of the hamstrings to the centre of the lower part of the space. The artery bifurcates on the level of a line corresponding to the tubercle of the tibia. It lies on the popliteal surface of the femur, the posterior ligament, and the popliteus. It is the second of these structures, which usually prevents popliteal aneurism and abscess from making their way into the joint. The **popliteal vein,** intimately adherent to the artery, lies to the outer side above, but crosses to its inner side below. The walls of this vein are thicker and denser than those of any other vein (Tillaux). The popliteal sheath is also unusually strong. The internal popliteal nerve crosses the artery in the same direction as the vein by which it is separated from the artery. This nerve is the direct continuation of the great sciatic nerve (fig. 753).

The **superior articular arteries** course outwards and inwards immediately above the condyles; the **inferior** ones lie just above the head of the fibula and below the internal tuberosity of the tibia (fig. 756). The deep part of the anastomotic artery runs in front of the tendon of the adductor magnus; the superficial with the internal saphenous nerve.

FIG. 753.—DEEP VIEW OF THE POPLITEAL SPACE. (Hirschfeld and Leveillé.)


Vastus externus
GREAT SCIATIC NERVE
Short head of biceps
EXTERNAL POPLITEAL NERVE
Long head of biceps, cut
Outer head of gastrocnemius
COMMUNICANS PERONEI NERVE
Soleus
Gastrocnemius
Adductor magnus
Popliteal vein
Popliteal artery
INTERNAL POPLITEAL NERVE
Vastus internus
Superior internal articular artery
Tendon of semi-membranosus
Inner head of gastrocnemius
Inferior internal articular artery
Popliteal vein
Popliteus
Tendon of plantaris
External saphenous vein and nerve

The **external saphenous vein** perforates the roof of the popliteal space in its lower part. As a rule, it is not visible unless enlarged.

The **popliteal glands** are not to be felt unless enlarged.

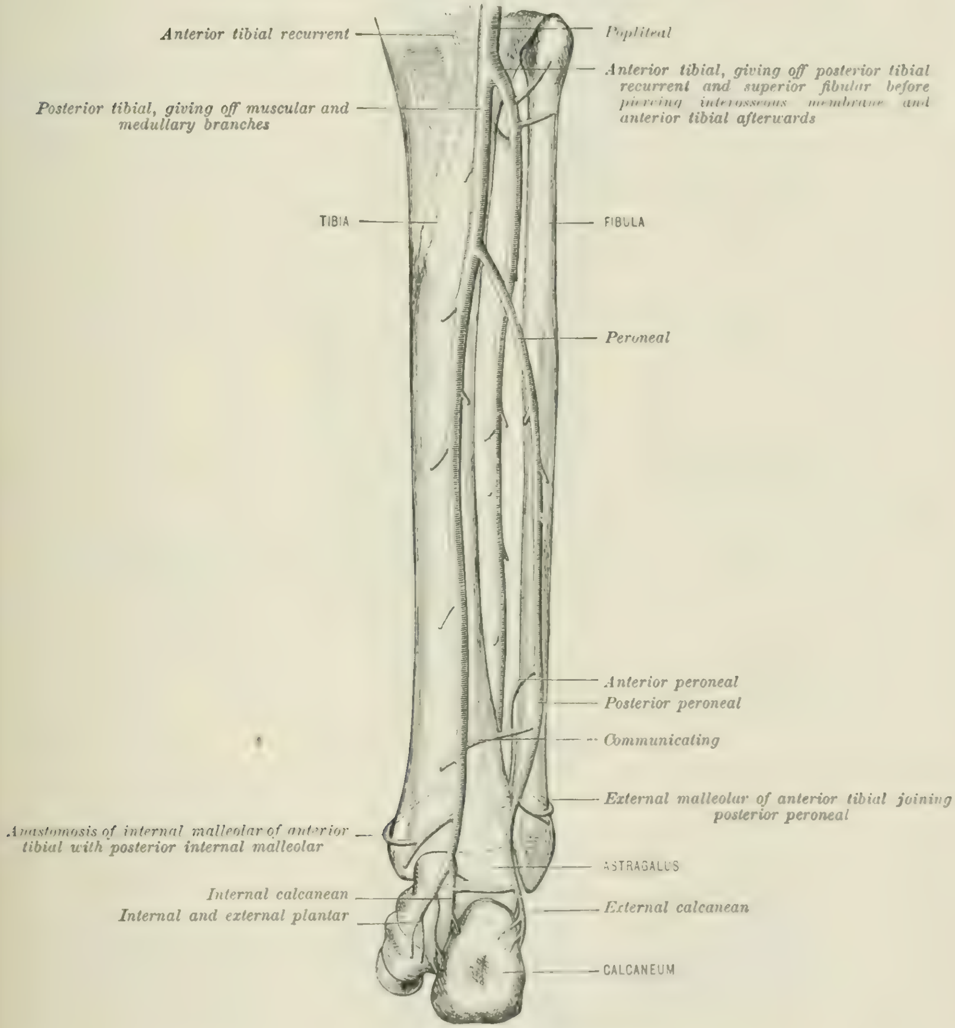
Bursæ in the popliteal space.—These have been already spoken of (page 1187).

THE LEG

Bony landmarks.—From the tubercle of the tibia descends the anterior border or 'shin.' This soon becomes sharp, and continues so for its upper two-thirds; in the lower third it disappears, to be overlaid by the extensor tendons. It is curved somewhat outwards above, and inwards below. The inner border can also be felt from the inner tuberosity to the internal malleolus. Between these two borders lies the internal surface, subcutaneous, save above, where it is covered by the three tendons of insertion of the gracilis and semi-tendinosus, and, overlying them, that of the sartorius. The tibia is narrowest and weakest at the junction of the middle and lower thirds, the most common site of fracture. Behind the internal malleolus, part of the groove for and the tendon of the tibialis posticus can be felt.

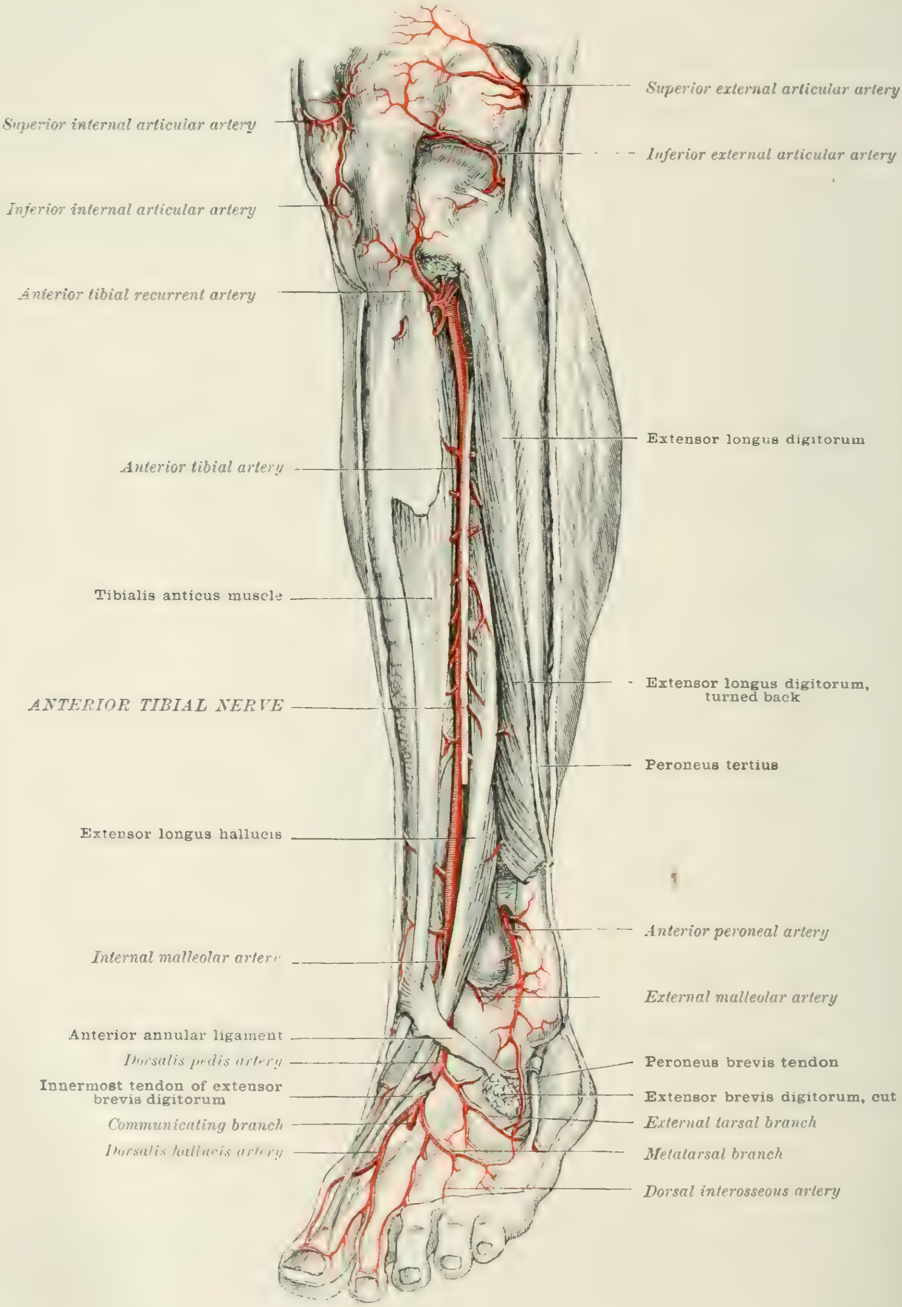
The head of the fibula can be felt distinctly, but the shaft soon becomes buried amongst muscles till about three inches above the external malleolus, where the bone expands into a large triangular subcutaneous surface. This lies between the peroneus tertius and the other two peronei. The peroneus longus overlaps the brevis, especially in the upper two-thirds of the leg. In the lower third the brevis tends to become anterior (fig. 756). Behind the external malleolus these tendons descend to the foot in very close relation to the bone. The shaft of the fibula is placed on a plane posterior to that of the tibia, and curves backwards in a direction reverse to that of the tibia.

FIG. 754.—ANASTOMOSES OF TIBIAL ARTERIES.


Anterior tibial recurrent
Popliteal
Anterior tibial, giving off posterior tibial recurrent and superior fibular before piercing interosseous membrane and anterior tibial afterwards
Posterior tibial, giving off muscular and medullary branches
TIBIA
FIBULA
Peroneal
Anterior peroneal
Posterior peroneal
Communicating
External malleolar of anterior tibial joining posterior peroneal
Anastomosis of internal malleolar of anterior tibial with posterior internal malleolar
ASTRAGALUS
Internal calcanean
External calcanean
Internal and external plantar
CALCANEUM

Muscular prominences.—The space between the tibia and fibula is mainly occupied by the fleshy belly of the tibialis anticus; outside this, and much less prominent, is the narrower extensor longus digitorum; outside this, again, are the peronei longus and brevis. Lower down, in an interval between the tibialis and the extensor of the toes, the extensor hallucis, here almost entirely tendinous, comes to the surface. Behind, the prominence of the calf is mainly formed by the gastrocnemius. On the patient's rising on tiptoe, the tendo Achillis starts into relief from about the middle of the leg. Of the two heads of the gastrocnemius, the inner is seen to be the larger. On either side of the tendon, but more distinctly on the

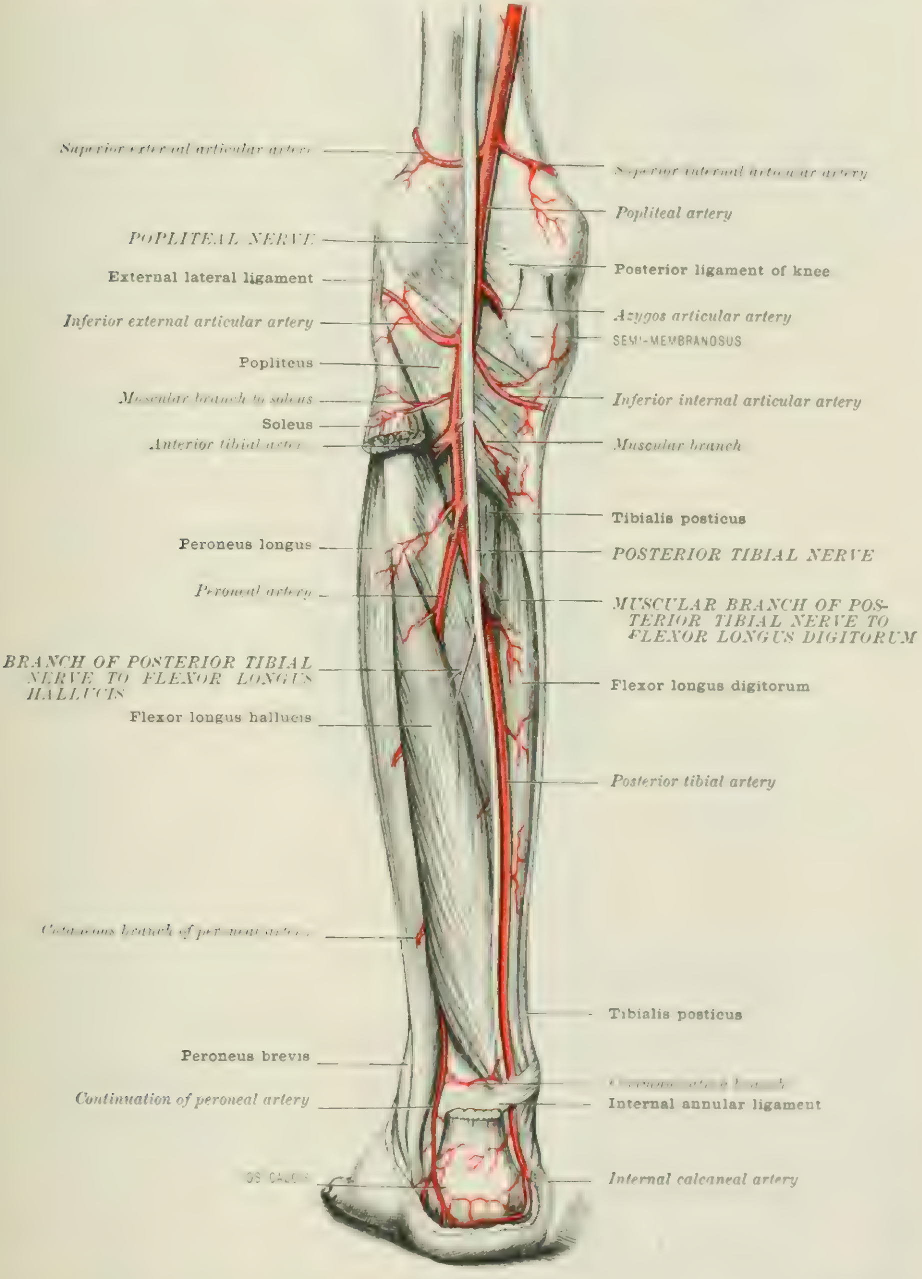
FIG. 755.—THE ANTERIOR TIBIAL ARTERY, DORSAL ARTERY OF THE FOOT, AND ANTERIOR PERONEAL ARTERY, AND THEIR BRANCHES.


Superior external articular artery
Superior internal articular artery
Inferior external articular artery
Inferior internal articular artery
Anterior tibial recurrent artery
Extensor longus digitorum
Anterior tibial artery
Tibialis anticus muscle
Extensor longus digitorum, turned back
ANTERIOR TIBIAL NERVE
Peroneus tertius
Extensor longus hallucis
Anterior peroneal artery
Internal malleolar artery
External malleolar artery
Anterior annular ligament
Dorsalis pedis artery
Peroneus brevis tendon
Innermost tendon of extensor brevis digitorum
Extensor brevis digitorum, cut
Communicating branch
External tarsal branch
Dorsalis hallucis artery
Metatarsal branch
Dorsal interosseous artery

outer side where it is less overlapped by the gastrocnemius, the soleus comes into view.

Vessels.—The **saphena veins** should be carefully traced, owing to the tendency of these and their branches to become varicose. The **internal**, having

FIG. 756.—RELATIONS OF THE POPLITEAL ARTERY TO BONES AND MUSCLES.

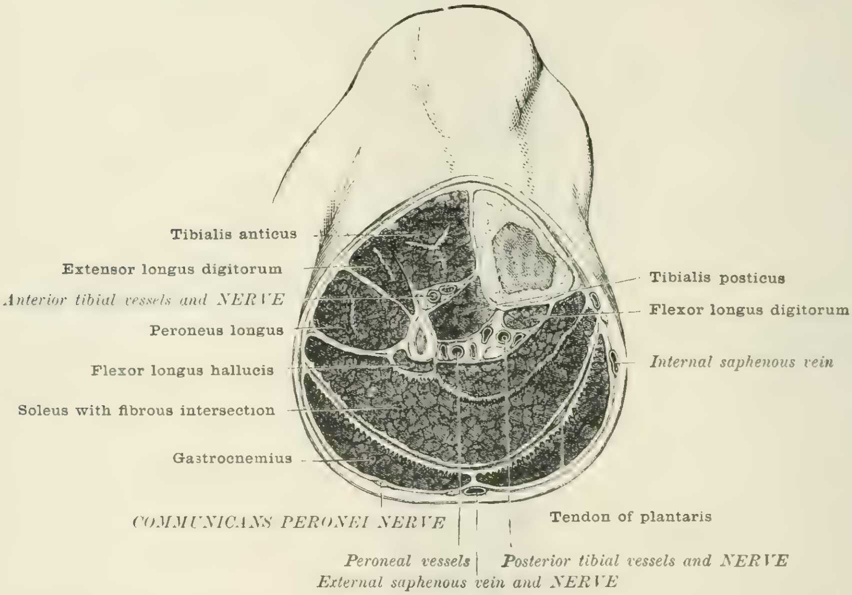

Superior external articular artery
Superior internal articular artery
Popliteal artery
POPLITEAL NERVE
Posterior ligament of knee
External lateral ligament
Inferior external articular artery
Azygos articular artery
SEMI-MEMBRANOSUS
Popliteus
Muscular branch to soleus
Inferior internal articular artery
Soleus
Anterior tibial artery
Muscular branch
Tibialis posticus
Peroneus longus
POSTERIOR TIBIAL NERVE
Peroneal artery
MUSCULAR BRANCH OF POSTERIOR TIBIAL NERVE TO FLEXOR LONGUS DIGITORUM
BRANCH OF POSTERIOR TIBIAL NERVE TO FLEXOR LONGUS HALLUCIS
Flexor longus digitorum
Flexor longus hallucis
Posterior tibial artery
Cutaneous branch of peroneal artery
Tibialis posticus
Peroneus brevis
Continuation of peroneal artery
Internal annular ligament
OS CALCIS
Internal calcaneal artery

passed from the arch on the dorsum over the internal malleolus, runs up the inner side of the leg, along the inner border of the tibia, to the back of the internal condyle, and then upwards along the thigh, over the roof of Hunter's canal, to the saphenous opening (page 1138 and fig. 769), where it joins the femoral. The internal saphenous nerve joins it below the knee, having been under the sartorius above this point (page 1178 and fig. 752). The **external** saphenous vein passes behind the external malleolus, runs upwards over the middle of the calf, and joins the popliteal by perforating the deep fascia in the lower part of the popliteal space. This vein is also accompanied by a nerve of the same name throughout its course.

The **popliteal artery** bifurcates at the lower border of the popliteus, about on a level with the tubercle of the tibia. About two inches lower down the peroneal artery comes off from the posterior tibial (fig. 756).

The course of the **posterior tibial** corresponds with a line drawn from the centre of the lower part of the popliteal space to a point midway between the tip of the internal malleolus and the inner edge of the calcaneum. In the lower third, the artery becomes somewhat superficial, passing from beneath the calf muscles, together with the tendons of the tibialis posticus and the flexor longus digitorum; and in a thin person it can be felt beating in the hollow on the inner side of the tendo Achillis (fig. 756).

FIG. 757.—SECTION OF THE RIGHT LEG IN THE UPPER THIRD. (Heath.)


Tibialis anticus
Extensor longus digitorum
Anterior tibial vessels and NERVE
Peroneus longus
Flexor longus hallucis
Soleus with fibrous intersection
Gastrocnemius
Tibialis posticus
Flexor longus digitorum
Internal saphenous vein
COMMUNICANS PERONEI NERVE
Tendon of plantaris
Peroneal vessels
Posterior tibial vessels and NERVE
External saphenous vein and NERVE

The course of the **anterior tibial artery** corresponds with a line drawn from a point midway between the outer tuberosity of the head of the tibia and the head of the fibula to one on the centre of the ankle-joint. This line corresponds to the outer border of the tibialis anticus and the interval between it and the extensor longus digitorum (figs. 755 and 758). This is shown when the first of these muscles is thrown into action.

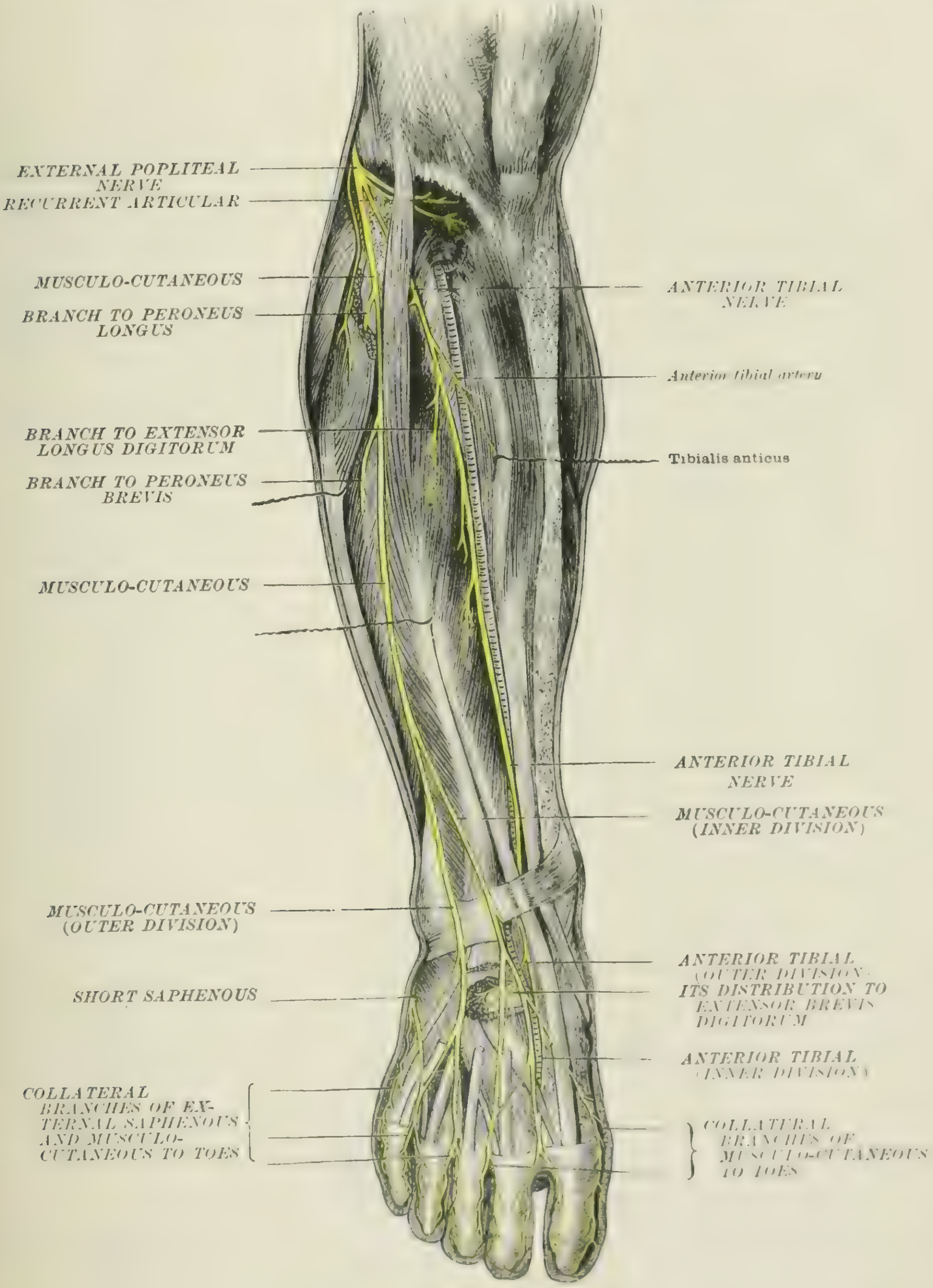
The **peroneal artery,** given off from the posterior tibial about an inch below the popliteus, or three inches below the head of the fibula, runs deeply along the inner border of this bone, covered by the flexor longus hallucis. It gives off the anterior peroneal to the front of the limb about an inch above the level of the ankle-joint.

The **nutrient artery** of the tibia arises from the posterior tibial near its commencement. It is the largest of all the nutrient arteries to the shafts of long bones.

As a general rule, in **amputation** one inch below the head of the fibula, only one main artery—the popliteal—is divided. In amputations two inches below the head of the fibula, two main arteries—the anterior and posterior tibials—are divided. In amputations three inches below the head, three main arteries—the two tibials and the peroneal—are divided (Holden).

In an amputation through the middle of the leg, the anterior tibial artery would be found cut on the interosseous membrane between the tibialis anticus and the extensor longus hallucis, its nerve lying to its inner side. The posterior tibial would be between the superficial and deep muscles at the back of the leg lying on

Fig. 758.—Branches of the External Popliteal Nerve.


EXTERNAL POPLITEAL NERVE
RECURRENT ARTICULAR
MUSCULO-CUTANEOUS
BRANCH TO PERONEUS LONGUS
BRANCH TO EXTENSOR LONGUS DIGITORUM
BRANCH TO PERONEUS BREVIS
MUSCULO-CUTANEOUS
MUSCULO-CUTANEOUS (OUTER DIVISION)
SHORT SAPHENOUS
COLLATERAL BRANCHES OF EXTERNAL SAPHENOUS AND MUSCULO-CUTANEOUS TO TOES
ANTERIOR TIBIAL NERVE
Anterior tibial artery
Tibialis anticus
ANTERIOR TIBIAL NERVE
MUSCULO-CUTANEOUS (INNER DIVISION)
ANTERIOR TIBIAL (OUTER DIVISION) ITS DISTRIBUTION TO EXTENSOR BREVIS DIGITORUM
ANTERIOR TIBIAL (INNER DIVISION)
COLLATERAL BRANCHES OF MUSCULO-CUTANEOUS TO TOES

the tibialis posticus, its nerve being to the outer side. The peroneal would be close to the fibula in the flexor longus hallucis.

The musculo-cutaneous nerve, having passed through the peroneus longus, and then between the peroneus longus and peroneus brevis, perforates the deep fascia in the lower third of the leg in the line of the septum between the peronei and extensors. Directly after, it divides into its two terminal branches.

THE ANKLE

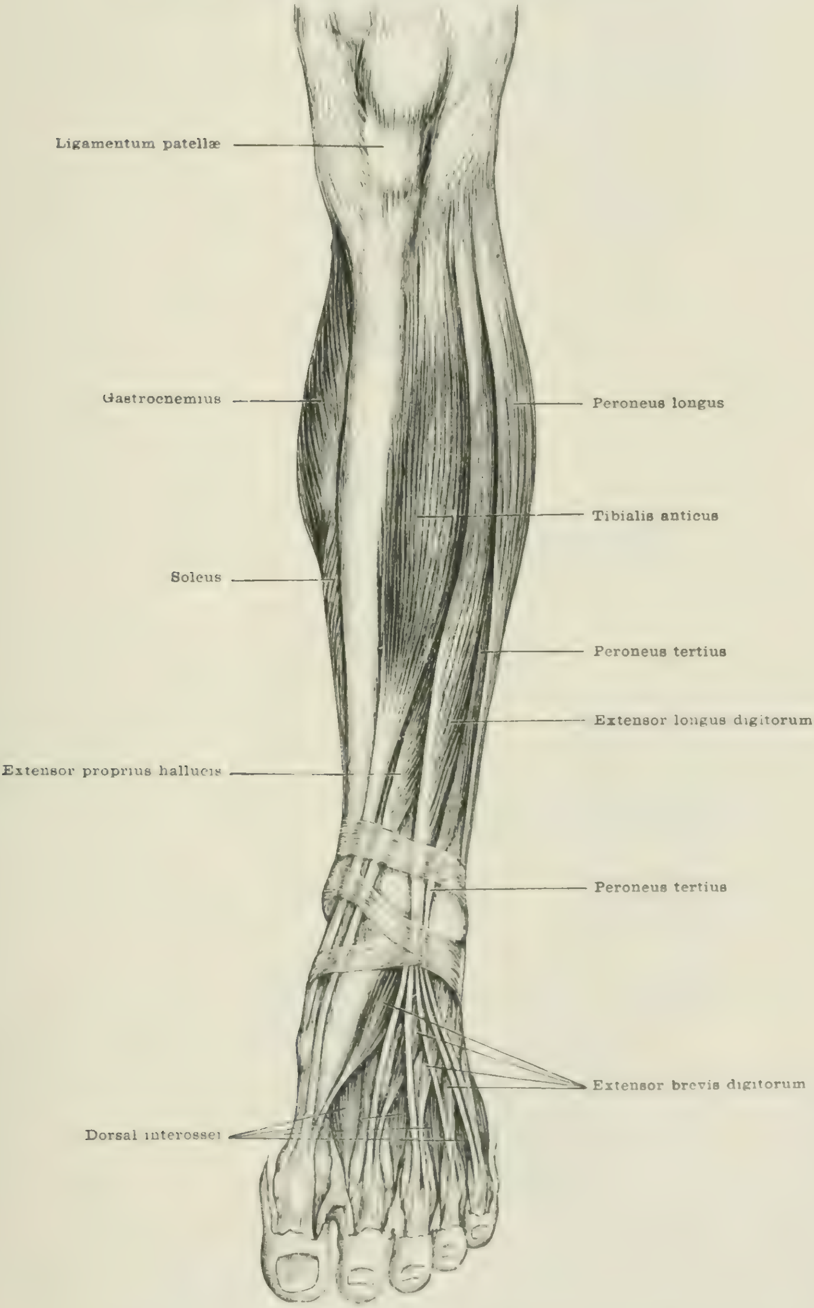
Bony landmarks.—Malleoli.—The following are the differences between them: The **internal** is the more prominent, shorter, and is placed more anteriorly than the outer, being a little in front of the centre of the joint. The **external** descends lower by a half to three-quarters of an inch, and thus securely locks in the joint on this side; it is opposite to the centre of the ankle-joint, being placed about half an inch behind its fellow. Owing, however, to the greater width of the internal malleolus, its posterior border is on a level with that of its fellow. The anterior margin of the lower end of the tibia can be traced above the ankle-joint, crossed by the tendons given below. Owing to the external malleolus descending lower than the inner, in Syme's and Pirogoff's amputations the incision should run between the tip of the external malleolus and a point half an inch below that of the internal one. When a fracture is set, or a dislocation adjusted, the inner edge of the patella, the internal malleolus, and the inner side of the great toe are useful landmarks and should be in the same vertical plane, regard being paid at the same time to the corresponding points in the opposite limb (Holden).

Tendons.—(A) **In front of ankle.**—From without inwards are—(1) The tibialis anticus, the largest and most internal. This tendon appears in the lower third of the leg, lying just under the deep fascia, close to the tibia; then, crossing over the lower end of this and the ankle-joint, it passes over the inner side of the tarsus, to be attached to the inner and lower part of the internal cuneiform and the adjacent part of the first metatarsal. (2) The extensor proprius hallucis. This tendon, concealed above, appears low down in a line just external to the last, and then, crossing over the termination of the anterior tibial vessels and nerves (to which its muscular part lies external), it descends along the inner part of the dorsum to be attached to the base of the last phalanx of the great toe. (3) and (4) The extensor longus digitorum and peroneus tertius enter a common sheath in the anterior annular ligament. The former then divides into four tendons, which, joined on the first phalanx by slips, three from the extensor brevis, and, a little later, by slips from the lumbricales and interossei, are inserted into the second and last phalanges, as in the fingers. The peroneus tertius is inserted into the upper surface of the base of the fifth metatarsal bone.

(B) **Behind.**—The tendo Achillis, the thickest of all tendons, begins near the middle of the leg, in the junction of the tendons of the gastrocnemii and soleus. Very broad at its commencement, it gradually narrows and becomes very thick. About an inch and a half from the heel, or about the level of the internal malleolus, is its narrowest point. After this it again expands slightly, to be attached to the middle of the back part of the calcaneum. The long tendon of the plantaris runs along its inner side, to blend with it or to be attached to the calcaneum. On either side of the tendo Achillis are well-marked furrows below. Along the inner, the tendon of the tibialis posticus and the posterior tibial vessels and nerve come nearer the surface. Along the outer, the external saphenous vein (more superficially) ascends from behind the external malleolus.

(C) **On the inner side.**—The tendon of the tibialis posticus, which has previously crossed from the interspace between the bones of the leg to the inner side, lies behind the inner edge of the tibia above the internal malleolus, being under the flexor longus digitorum, the two tendons here becoming superficial on the inner side of the tendo Achillis. It then passes forwards close below the sustentaculum tali and the head of the astragalus, and then very close to the inferior calcaneo-scaphoid ligament (*vide infra*), and so to its insertion, by numerous slips, into the tarsus and metatarsus, especially the tubercle of the scaphoid. The tendon of the flexor longus hallucis cannot be felt. Having passed internally from the fibula, it crosses the lower end of the tibia in a separate furrow, then grooves the back of the astragalus, and passes under the sustentaculum tali on its way to its insertion. The arrangement of the structures at the inner ankle from above downwards, and from within onwards, is as follows (fig. 761):—tibialis posticus, flexor

FIG. 759.—THE MUSCLES OF THE FRONT OF THE LEG.


Ligamentum patellæ
Gastrocnemius
Peroneus longus
Tibialis anticus
Soleus
Peroneus tertius
Extensor longus digitorum
Extensor proprius hallucis
Peroneus tertius
Extensor brevis digitorum
Dorsal interossei

longus digitorum, companion vein, posterior tibial artery, companion vein, posterior tibial nerve, flexor longus hallucis.

(D) **Tendons at outer ankle.**—The tendons of the two peronei, which arise from the fibula between the extensor longus digitorum and flexor longus hallucis, pass behind the external malleolus, the brevis being nearer to the bone (fig. 758). They then pass forwards over the outer surface of the calcaneum, separated by the peroneal tubercle when present, and diverge. The brevis—the upper one—passes to the projection at the base of the fifth metatarsal; the longus, lying below the brevis on the calcaneum, winds round the outer border of the foot, grooving the outer border and under surface of the cuboid. Finally, crossing the sole obliquely forwards and inwards, it is attached to the adjacent parts of the internal cuneiform and the back part and under surface of the first metatarsal. While in connection with the under surface of the cuboid, this tendon is covered in by a sheath from the long plantar ligament, and often contains a sesamoid bone.

FIG. 760.—TRANSVERSE SECTION THROUGH THE LOWER THIRD OF THE LEFT LEG, IMMEDIATELY ABOVE THE ANKLE-JOINT. (Braune.)

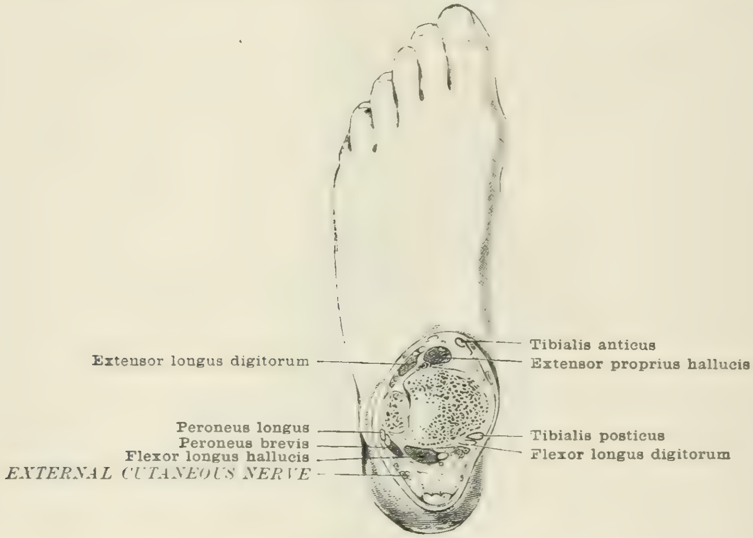
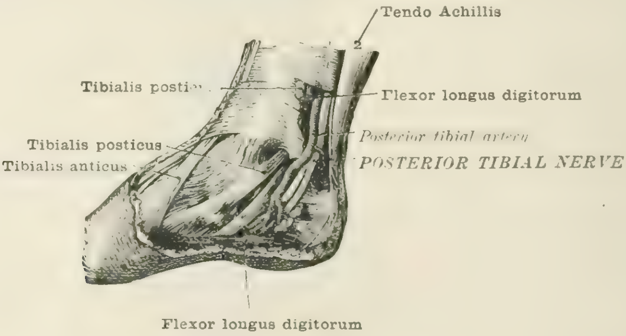

Tibialis anticus
Extensor longus digitorum
Extensor proprius hallucis
Peroneus longus
Peroneus brevis
Flexor longus hallucis
EXTERNAL CUTANEOUS NERVE
Tibialis posticus
Flexor longus digitorum

FIG. 761.—RELATIONS OF PARTS BEHIND THE INNER MALLEOLUS. (Heath.)


Tendo Achillis
2
Tibialis posti
Flexor longus digitorum
Posterior tibial artery
Tibialis posticus
Tibialis anticus
POSTERIOR TIBIAL NERVE
Flexor longus digitorum

Annular ligaments and synovial membranes of tendons.—These strap-like bands of deep fascia, which serve to keep the above tendons in position, are three in number, viz.:—

(A) **External.**—This extends from the tip of the external malleolus to the outer surface of the calcaneum. It keeps the two peronei in place, and surrounds them behind the fibula in one sheath with a single synovial sac, which extends upwards into the leg for an inch and a half, and sends two processes into the two sheaths in which the tendons lie on the calcaneum. Farther on, while in relation with the cuboid, the peronei longus has a second synovial sheath.

(B) **Internal.**—This crosses from the internal malleolus to the inner surface of the calcaneum. Beneath it are the following canals: (1) For the tibialis posticus. This tendon-sheath is lined by a synovial membrane extending from a point an inch and a half above the malleolus to the scaphoid. (2) For the flexor longus digitorum. The synovial sheath of this tendon is separate from that of the closely contiguous tibialis posticus. It extends upwards into the leg about as high as the sheath just given. It reaches down into the sole of the foot; but where the tendon subdivides to enter the thecae, each of these is lined by a separate synovial sheath. Next comes (3) a wide space for the posterior tibial vessels and nerve; and, lastly, (4) a canal, like the other two, with a separate synovial sheath, for the tendon of the flexor longus hallucis.

(C) **Anterior annular ligament.**—This is a double structure. (1) **Upper, above the level of the ankle-joint,** and tying the tendons down to the lower third of the leg, it passes transversely between the anterior crest of the tibia and fibula. Here is one sheath only, with a synovial membrane for the tibialis anticus. (2) **Lower, over the ankle-joint.** This band is arranged like the letter <, placed thus (fig. 759). It is attached by its root to the calcaneum, and by its bifurcations to the internal malleolus and the fascia of the sole. This arrangement of the branches of this ligament is not constant. In this, the lower annular ligament, there are usually three sheaths with separate synovial membranes—the innermost (the strongest in each) for the tibialis anticus, the next for the extensor proprius hallucis, and the third common to the extensor communis and peroneus tertius.

Points in tenotomy and guides to the tendons.—The **tendo Achillis** should be divided about an inch and a half above its insertion, its narrowest point, which is about on a level with the internal malleolus. The knife should be introduced on the inner side and close to the tendon, so as to avoid the posterior tibial artery (fig. 756).

The **tibialis anticus** is often cut about an inch above its insertion into the internal cuneiform, a point which is below the level of its synovial sheath. The tendon has here the dorsalis pedis on its outer side, but separated by the tendon of the extensor proprius hallucis. The knife is introduced on this side.

The tibialis posticus.—The usual rule for dividing this tendon is to take a spot two inches above the internal malleolus, and as accurately as possible midway between the anterior and internal borders of the leg. This point will give the inner margin of the tibia, in close apposition to which the tendon is lying, and is a point at which the tendon is rather farther from the artery than it is below, and is also above the commencement of its synovial sheath. A sharp-pointed knife is used first to open the sheath freely, and then a blunt-pointed one to divide the tendon. The flexor longus digitorum is usually cut at the same time.

Owing to the great difficulty in making sure of dividing the tibialis posticus tendon at this spot, and the risk of cutting the posterior tibial artery (fig. 756), it has been advised of late years (Parker) to divide this tendon together with that of the anticus simultaneously by an incision a little below and anterior to the tip of the internal malleolus. Other guides are the position of the astragalo-scaphoid joint, and, where the deformity is of some standing, the crease which denotes the inversion of the foot. The position of the two tibial arteries should be noted, and also the lines along which the tendons are converging—the one across the lower end of the tibia, the other from behind the tibia and below the sustentaculum tali to the line of the scaphoid and internal cuneiform. Mr. R. W. Parker has named this operation syndesmotomy, as he rightly considers that the astragalo-scaphoid ligaments require division at the same time.

Peronei.—The peronei, longus and brevis, may be divided two inches above the external malleolus, so as to be above the level of their synovial sheath. The knife should be inserted very close to the bone, so as to pass between the fibula and the tendons. Division below the external malleolus is somewhat easier, but as this opens their synovial sheath or sheaths (*vide supra*, page 1197), it requires scrupulous care as to cleanliness.

THE FOOT

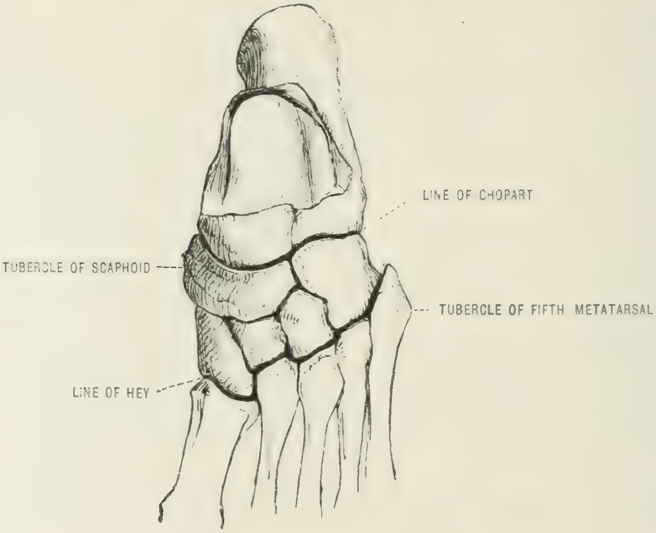
Bony landmarks.—The following are of the greatest practical importance owing to the operations which are performed upon the foot.

(A) **Along the inner aspect of the foot** are the following:—

(1) Internal tuberosity of the calcaneum; (2) internal malleolus; (3) one full inch below the malleolus, the sustentaculum tali; (4) about an inch in front of the internal malleolus, and a little lower, is the tubercle of the scaphoid, the gap between it and the sustentaculum being filled by the calcaneo-scaphoid ligament and the tendon of the tibialis posticus, in which there is often a sesamoid bone; (5) the internal cuneiform; (6) the base of the first metatarsal; and (7) the head of the same bone, with its sesamoid bones below (Holden).

(B) **Along the outer aspect** are—(1) The outer tuberosity of the calcaneum; (2) the external malleolus; (3) the peroneal tubercle of the calcaneum (when present), one inch below the malleolus, with the long peroneal tendon below it, and the short one above; (4) the projection of the anterior end of the calcaneum, and the calcaneo-cuboid joint, midway between the tip of the external malleolus and the base of the fifth metatarsal bone; (5) the base of the fifth metatarsal bone; (6) the head of this bone.

Fig. 762.—Articulations of the Foot, Dorsal Aspect. (Bellamy.)



Levels of joints and lines of operations.—In **Syme's amputation** through the ankle-joint, the incision starts (say in the case of the left foot) from the tip of the external malleolus, and is then carried, pointing a little backwards towards the heel, across the sole to a point half an inch below the internal malleolus.

In **Pirogoff's amputation** the incision begins and ends at the same points, but is carried straight across the sole. In each amputation the extremities of the above incision are joined by one going straight across the ankle-joint, which lies about half an inch above the tip of the internal malleolus.

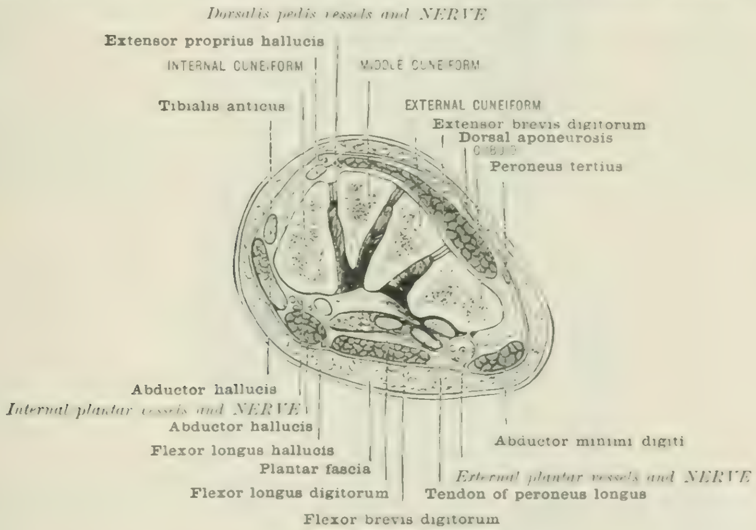
In **Chopart's medio-tarsal amputation** (fig. 762), which passes between the astragalus and the scaphoid on the inner side, and the calcaneum and the cuboid on the outer, the line of the joints to be opened would be one drawn across the dorsum from a point just behind the tuberosity of the scaphoid to a point corresponding to the calcaneo-cuboid joint, just midway between the tip of the external malleolus and the base of the fifth metatarsal bone.

In **Lisfranc's**, or **Hey's**, or the **tarso-metatarsal amputation**, the bases of the fifth and first metatarsals must be defined. The first of these can always be detected, even in a stout or swollen foot: on the inner side the joint between the internal cuneiform and the first metatarsal bone lies an inch and a half in front of the scaphoid tubercle. In opening the joint between the second metatarsal and the middle cuneiform, its position (the base of the former bone projecting upwards on to a level one-third or one-fourth of an inch above the others), and the way in which it is locked in between its fellows and the cuneiform bones, must be remembered.

In marking out the flaps for the **amputation of the great toe**, the large size of the head of the first metatarsal, and the importance of leaving this so as not to diminish its supporting power and the treading width of the foot, and thus of marking out flaps sufficiently long and large, must be borne in mind. In amputation of the other toes, the line of their metatarso-phalangeal joints lies a full inch above the web.

Bursæ and synovial membranes.—The synovial sheath of the extensor proprius hallucis extends from the front of the ankle, over the instep, as far as the metatarsal bone of the great toe. There is generally a bursa over the instep, above, or it may be below, the tendon. There is often an irregular bursa between the tendons of the extensor longus digitorum and the projecting end of the astragalus over which the tendons play. There is much friction here. It is well to be aware that this bursa sometimes communicates with the joint of the head of the astragalus (Holden). There is a deep synovial bursa between the tendo Achillis and the calcaneum. Numerous other bursæ may appear over any of the bony points in the foot, especially when they are rendered over-prominent by morbid conditions.

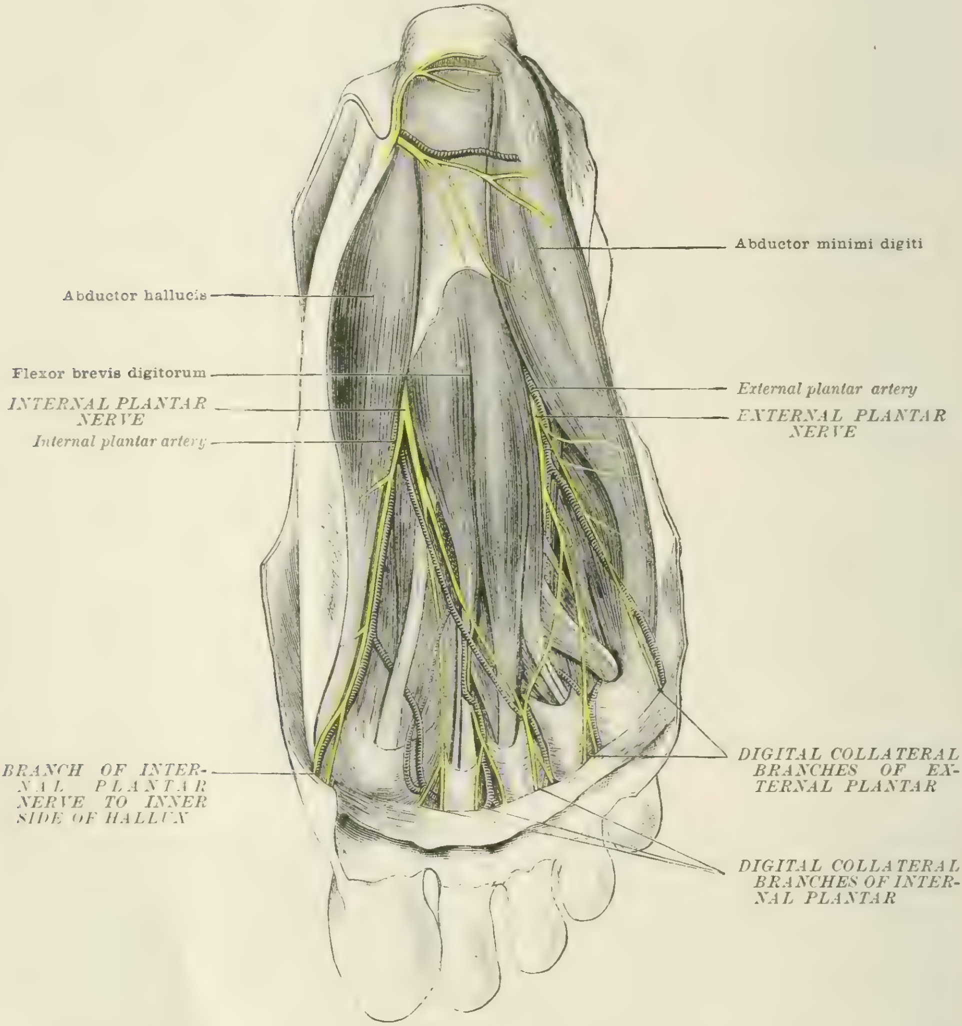
FIG. 763.—VERTICAL SECTION THROUGH THE CUNEIFORM AND CUBOID BONES. (One-half.)


Dorsalis pedis vessels and NERVE
Extensor proprius hallucis
INTERNAL CUNEIFORM
MIDDLE CUNEIFORM
Tibialis anticus
EXTERNAL CUNEIFORM
Extensor brevis digitorum
Dorsal aponeurosis
CUBOID
Peroneus tertius
Abductor hallucis
Internal plantar vessels and NERVE
Abductor hallucis
Flexor longus hallucis
Plantar fascia
Flexor longus digitorum
Abductor minimi digiti
External plantar vessels and NERVE
Tendon of peroneus longus
Flexor brevis digitorum

Synovial membranes.—In addition to that of the ankle-joint, there are **six** synovial membranes in the **tarsus**, viz.:—(1) Posterior calcaneo-astragaloid, peculiar to these bones; (2) anterior calcaneo-astragaloid, common to these bones and the scaphoid; (3) between the calcaneum and the cuboid; (4) between the cuboid and the outer two metatarsals; (5) between the internal cuneiform and the first metatarsal; (6) a complicated and extensive one, which branches out between the scaphoid and cuneiform bones; between the cuneiforms; between the external cuneiform and the cuboid; between the middle and outer cuneiform and the second and third metatarsal bones; and between the second and third, and the third and fourth metatarsal bones (fig. 762).

Dorsal artery.—The line of this is from the centre of the ankle-joint to the upper part of the first interosseous space. On its inner side is the tendon of the extensor proprius hallucis; on its outer, the innermost tendon of the extensor longus digitorum. It is crossed by the innermost tendon of the extensor brevis. The origin of this muscle should be marked on the outer and fore part of the calcaneum.

FIG. 764.—SUPERFICIAL NERVES IN THE SOLE OF THE FOOT. (Ellis.)


Abductor minimi digiti
Abductor hallucis
Flexor brevis digitorum
External plantar artery
INTERNAL PLANTAR NERVE
EXTERNAL PLANTAR NERVE
Internal plantar artery
BRANCH OF INTERNAL PLANTAR NERVE TO INNER SIDE OF HALLUX
DIGITAL COLLATERAL BRANCHES OF EXTERNAL PLANTAR
DIGITAL COLLATERAL BRANCHES OF INTERNAL PLANTAR

Cutaneous nerves (figs. 764, 770).—The sites of these, numerous on the dorsum of the foot, are as follows:—The **musculo-cutaneous nerve,** having perforated the fascia in the lower third of the leg, divides into two chief branches, inner and outer, which supply all the toes save the outer part of the little, and the adjacent sides of the first and second. The **anterior tibial** becomes cutaneous in the first space, and is distributed to the contiguous sides of the above-mentioned toes. The **external saphenous nerve** runs with its vein below the malleolus, and supplies all the outer border of the foot and the outer side of the little toe. The **internal saphenous nerve,** coursing with its vein in front of the internal

FIG. 765.—PLANTAR ARTERIES (DEEP).

(From a dissection in the Hunterian Museum.)

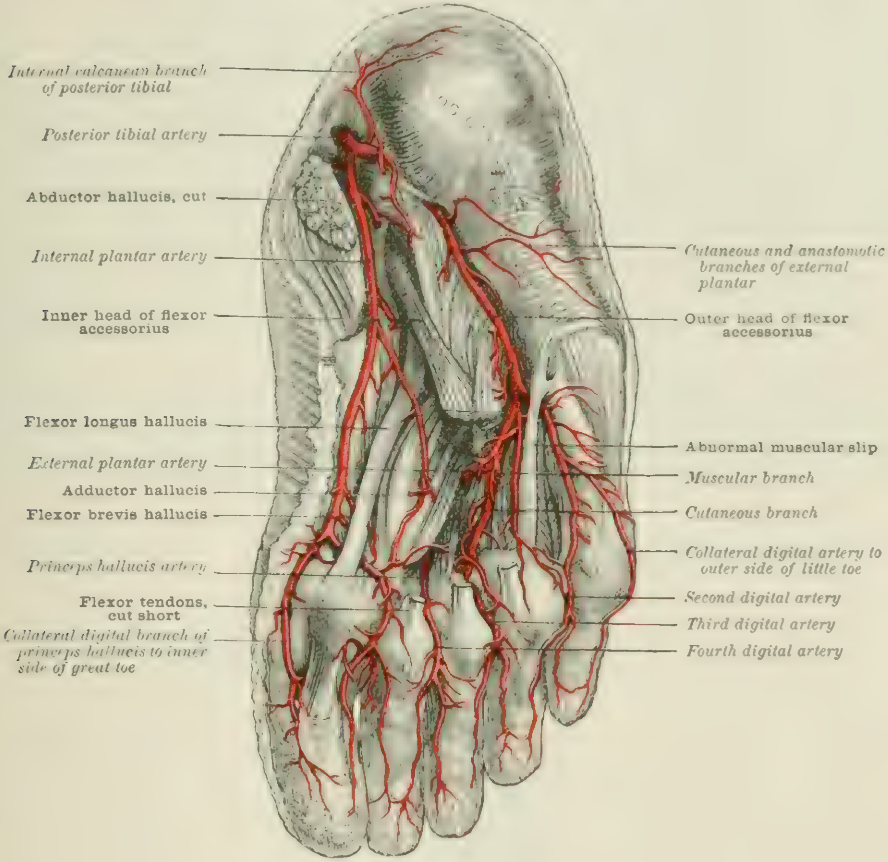
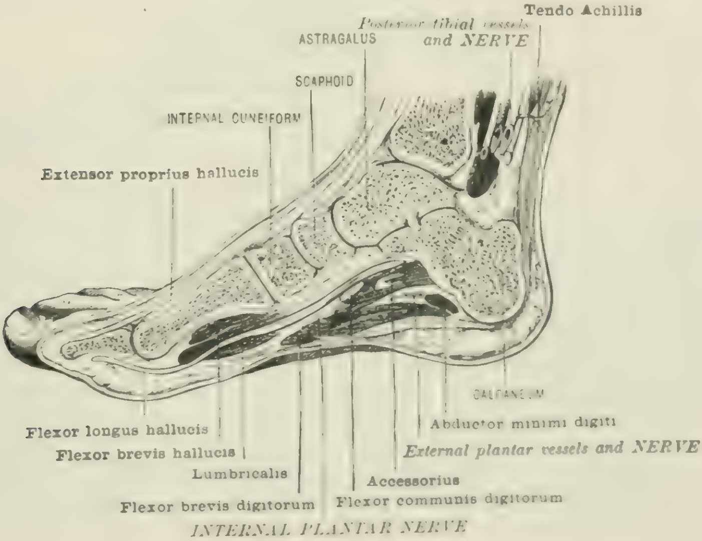

Internal calcanean branch of posterior tibial
Posterior tibial artery
Abductor hallucis, cut
Internal plantar artery
Inner head of flexor accessorius
Flexor longus hallucis
External plantar artery
Adductor hallucis
Flexor brevis hallucis
Princeps hallucis artery
Flexor tendons, cut short
Collateral digital branch of princeps hallucis to inner side of great toe
Cutaneous and anastomotic branches of external plantar
Outer head of flexor accessorius
Abnormal muscular slip
Muscular branch
Cutaneous branch
Collateral digital artery to outer side of little toe
Second digital artery
Third digital artery
Fourth digital artery

FIG. 766.—LONGITUDINAL SECTION OF FOOT. (One-third.) (Braune.)


Tendo Achillis
Posterior tibial vessels and NERVE
ASTRAGALUS
SCAPHOID
INTERNAL CUNEIFORM
Extensor proprius hallucis
CALCANEUM
Abductor minimi digiti
External plantar vessels and NERVE
Accessorius
Flexor communis digitorum
Flexor longus hallucis
Flexor brevis hallucis
Lumbricalis
Flexor brevis digitorum
INTERNAL PLANTAR NERVE

malleolus, supplies the inner border of the foot as far as the middle of the instep.

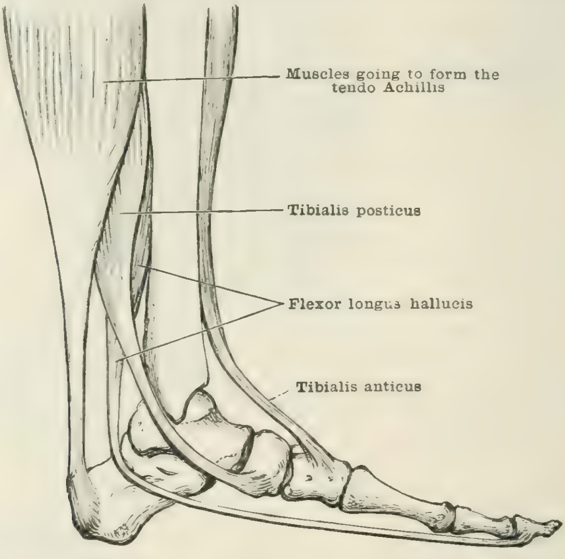
Plantar arteries.—The line of the internal would be one drawn from the bifurcation of the posterior tibial, or about midway between the tip of the internal malleolus and the inner border of the heel, to the middle of the plantar surface of the great toe. The course of the external plantar runs in a line drawn from the bifurcation, first obliquely across the foot to a point a little internal to the inner side of the base of the fifth metatarsal, and thence obliquely across the foot till it reaches the first space and joins with a communicating branch from the dorsal artery. It thus crosses the foot twice. In the first part, it is more superficial, in the second very deep; it here forms the plantar arch, and is only separated from the bases of the metatarsals by the interossei.

ARCHES OF THE FOOT

These are two—the **longitudinal** and the **transverse.**

(A) **Longitudinal arch** (figs. 766, 767, and 768).—This is by far the most important. **Extent**: From the heel to the heads of the metatarsal bones. The toes do not add much to the strength and elasticity of the foot (Humphry). They enlarge its area and adapt it to inequalities of the ground, are useful in climbing, and in giving an impulse to the step before the foot is taken from the ground, in the third stage of walking. **Two pillars.**—Professor Humphry lays stress on the important differences between these two: (1) **Posterior pillar**: This consists of the calcaneum and hinder part of the astragalus, viz. only two bones in order to secure solidity, and to enable the calf-muscles to act directly upon the heel, without any of that loss of power which would be brought about by many moving joint-surfaces. (2) **Anterior pillar**: Here there are many bones and joints to provide (*a*) elastic springiness, and (*b*) width. This anterior pillar may again be divided into two: (*a*) An **inner pillar**, very elastic, consisting of the astragalus, scaphoid, three cuneiforms, and three inner metatarsals. (*b*) An **outer,** formed by the cuboids and two outer metatarsals. This is stronger and less elastic, and tends to buttress up the inner pillar. **Keystone**: This is represented by the summit of the trochlear surface of the astragalus. It differs from the keystones in ordinary

Fig. 767.—The Arch in the Ordinary Position of Standing. (Ellis, of Gloucester.)

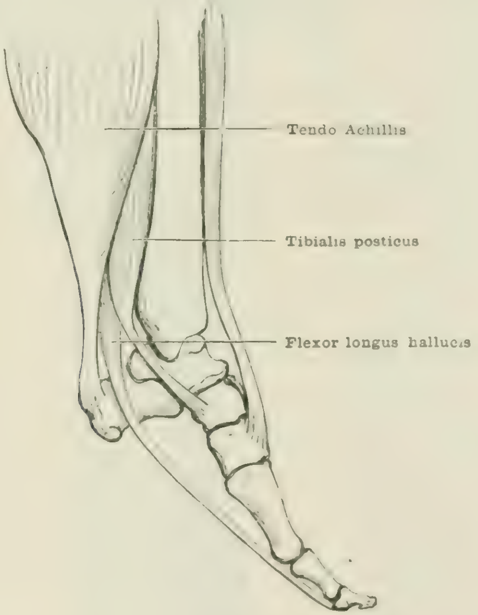


arches in the following important particulars (Humphry): (*a*) in not being wedge-shaped; (*b*) in not being so placed as to support and receive support from the two halves of the arch: in front the astragalus does fulfil this condition by fitting into the scaphoid; behind, it overlaps the calcaneum without at all supporting it; (*c*) this arch and the support of its keystone largely depend on ligaments and tendons; (*d*) it is a mobile keystone: to give it chances of shifting its pressure, and so obtaining rest, its equilibrium is not always maintained in one position.

(B) **Transverse arch** (fig. 763).—This is best marked about the centre of the foot, at the instep, along the tarso-metatarsal joints. This, as well as the longitudinal arch, yields in walking, and so gives elasticity and spring.

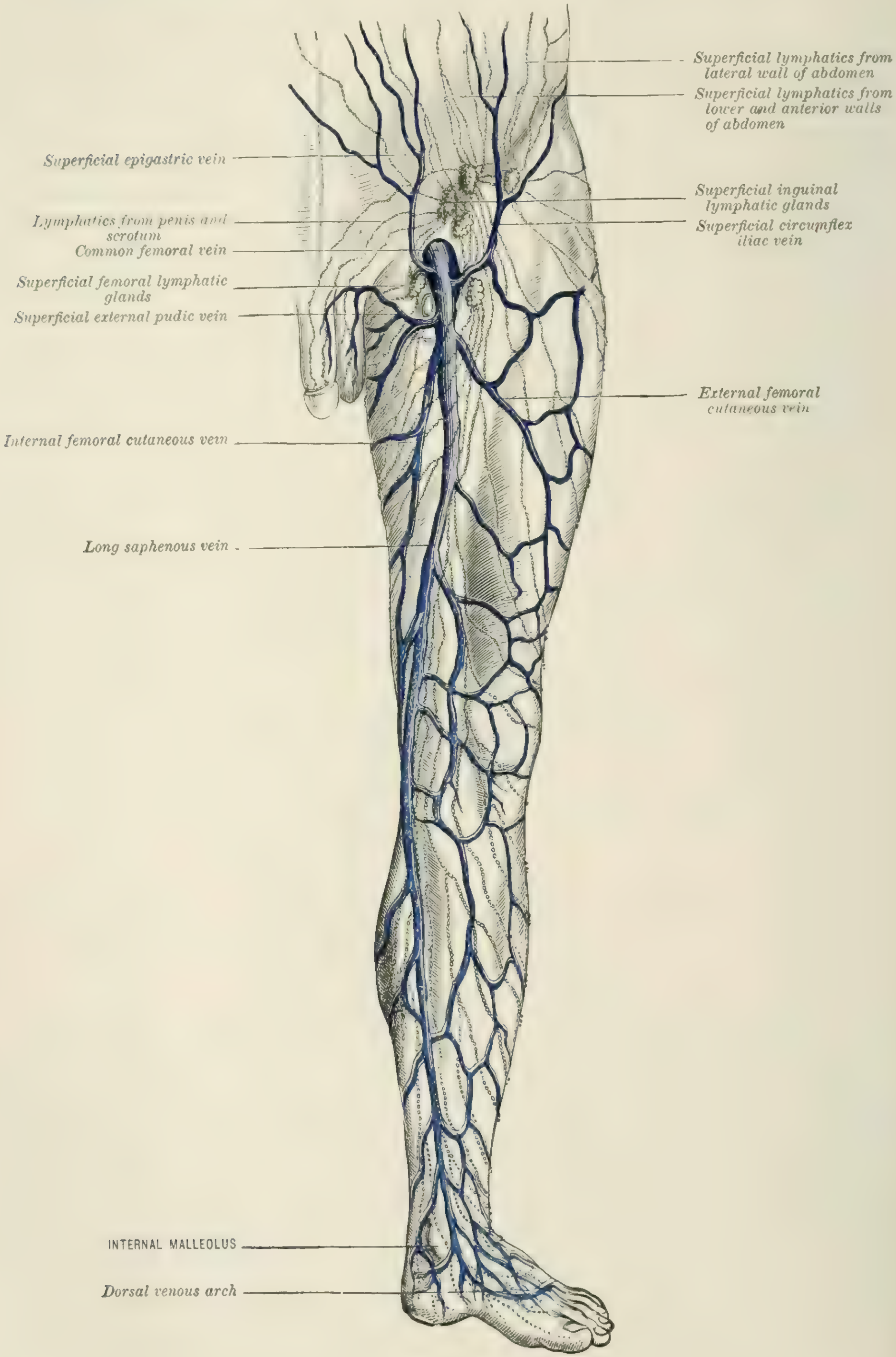
Uses of the arches.—(1) They give combined elasticity and strength to the tread. Thus they give firmness, free quickness, and dignity, both in standing and walking, instead of what we see in their absence, viz. the lameness of an artificial limb, and the shuffling or hobbling which goes with tight boots, deformed toes, flat-foot, bunions, corns, etc.; (2) they protect the plantar vessels, nerves, and muscles; (3) they add to man's height; (4) they make his gait a perfect combination of plantigrade and digitigrade, as is seen in man's walking, when he uses first the heel, then all the foot, and then the toes (Humphry).

FIG. 768.—THIS SHOWS THE EFFECT OF MUSCULAR ACTION IN THROWING UP THE ARCH.



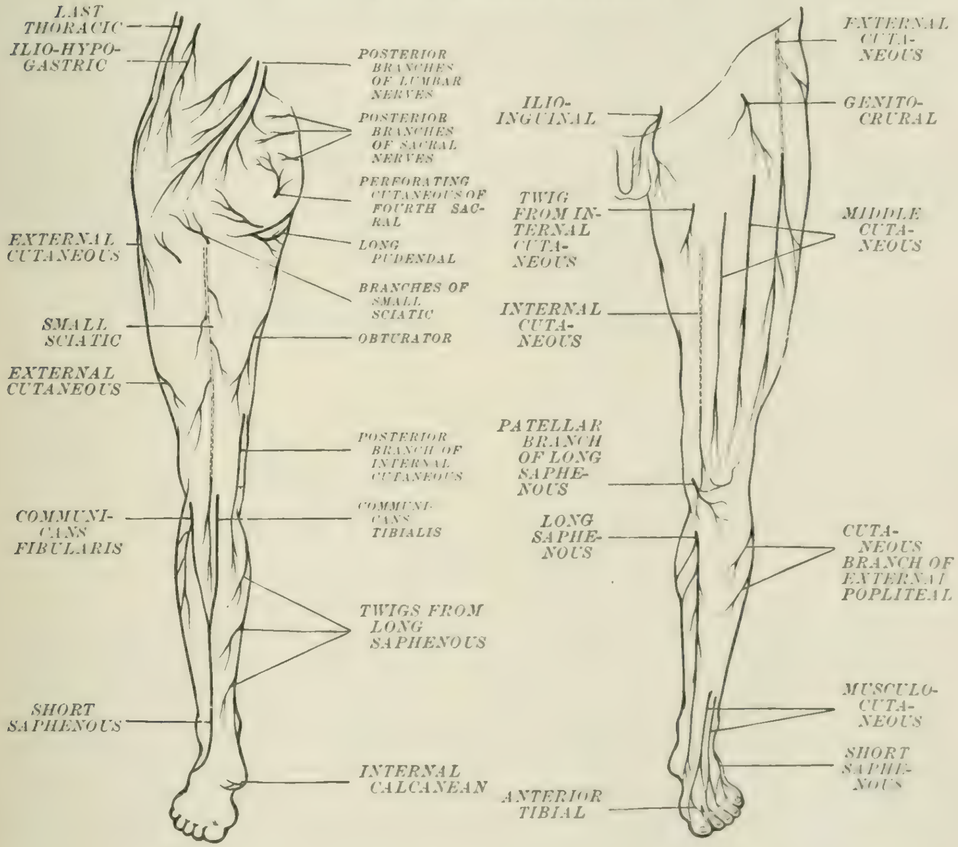
Maintenance of the arch.—(1) **Plantar fascia.**—This is (*a*) a binding tie between the pillars of the longitudinal arch; (*b*) it protects the structures beneath; (*c*) it is a self-regulating ligament and protection. Thus, having a quantity of muscular tissue attached to its upper and back part, it constantly responds by the contraction of this, to the amount of any pressure made upon the foot. (2) **Calcaneo-scaphoid ligament.**—This is a thick plate of fibrous tissue, partly elastic, attached to the under surface of the calcaneum, sustentaculum tali, and scaphoid. It is thickest at its inner side, where it blends with the anterior part of the deltoid ligament, and where the tibialis posticus passes into the sole, giving much support to the head of the astragalus, and assisting the power and spring of this ligament (*vide infra*). (3) **Calcaneo-cuboid ligaments.** (*a*) **Long**; (*b*) **short.**—These ligaments are the main support of the outer, firm, and less elastic part of the longitudinal arch. (4) **Tibialis posticus.**—The reason of this muscle having so many insertions below is to brace together the tarsal bones, and to prevent

FIG. 769.—THE SUPERFICIAL VEINS AND LYMPHATICS OF THE LEFT LOWER LIMB.


Superficial lymphatics from lateral wall of abdomen
Superficial lymphatics from lower and anterior walls of abdomen
Superficial epigastric vein
Superficial inguinal lymphatic glands
Lymphatics from penis and scrotum
Superficial circumflex iliac vein
Common femoral vein
Superficial femoral lymphatic glands
Superficial external pudic vein
External femoral cutaneous vein
Internal femoral cutaneous vein
Long saphenous vein
INTERNAL MALLEOLUS
Dorsal venous arch

their separation when, in treading, the elastic anterior pillar tends to widen out. Of these numerous offsets, that to the scaphoid is the most important. Thus it strengthens the calcaneo-scaphoid ligament by blending with it, and thus supports the arch at a trying time. By coming into action when the heel is raised (fig. 768), this tendon helps the calcaneo-scaphoid ligament to support the head of the astragalus, and to maintain the arch of the foot when the weight of the body is thrown forward on to the instep. In other words, the tibialis posticus comes into play just when the heaviest of its duties is devolving upon this ligament, viz. when the heel is being raised, and the body-weight is being thrown over the instep on to the opposite foot. (5) **Peroneus longus.**—This raises the outer pillar, and steadies the outer side of the arch. Further, by its strong process attached to the first metatarsal bone, it keeps the great toe strapped down firmly against the ground; thus, keeping down the anterior pillar of the longitudinal arch, it aids the firmness of the tread (Humphry). (6) **Tibialis anticus.**—This braces up the keystone of the arch. Thus, by keeping up the internal cuneiform, it maintains the scaphoid, and so indirectly the astragalus, *in situ.*

FIG. 770.—DISTRIBUTION OF CUTANEOUS NERVES ON THE POSTERIOR AND ANTERIOR ASPECTS OF THE INFERIOR EXTREMITY.


LAST THORACIC
ILIO-HYPOGASTRIC
EXTERNAL CUTANEOUS
SMALL SCIATIC
EXTERNAL CUTANEOUS
COMMUNICANS FIBULARIS
SHORT SAPHENOUS
POSTERIOR BRANCHES OF LUMBAR NERVES
POSTERIOR BRANCHES OF SACRAL NERVES
PERFORATING CUTANEOUS OF FOURTH SACRAL
LONG PUDENDAL
BRANCHES OF SMALL SCIATIC
OBTURATOR
POSTERIOR BRANCH OF INTERNAL CUTANEOUS
COMMUNICANS TIBIALIS
TWIGS FROM LONG SAPHENOUS
INTERNAL CALCANEAN
ILIO-INGUINAL
TWIG FROM INTERNAL CUTANEOUS
INTERNAL CUTANEOUS
PATELLAR BRANCH OF LONG SAPHENOUS
LONG SAPHENOUS
ANTERIOR TIBIAL
EXTERNAL CUTANEOUS
GENITO-CRURAL
MIDDLE CUTANEOUS
CUTANEOUS BRANCH OF EXTERNAL POPLITEAL
MUSCULO-CUTANEOUS
SHORT SAPHENOUS

(7) Dr. Ellis (of Gloucester) has drawn especial attention to the action of the long flexors as bow-strings or tie-rods as they tighten in their contraction, and so diminish the distance between their points of attachments to the toes and the spot where the tendons pass round the os calcis, thus bracing up the arch. Of these flexors the flexor longus hallucis has especial influence, as shown by the stage-dancer, who supports herself literally on one toe. The flexor longus digitorum, while of less influence than the flexor longus hallucis, serves two important

purposes, one of passing beneath and thus picking up the other one, the flexor longus hallucis. Further, it draws the four smaller toes firmly against the ground, the object of the smaller toes being, as far as possible, to grip the ground. (8) The same authority points out that the possession by the great toe of two phalanges only is to enable it to form a firm solid base, on which not only the flexor longus hallucis and the peroneus longus act, but also the smaller muscles, by holding this toe down and keeping it straight in all its length. The two heads of the short flexor, the abductor and adductor, 'one pulling one way and one in the opposite direction, and like the two reins of a bridle when both are pulled together, have a joint or a collective action.' The above three short muscles are to be regarded as one set of flexor muscles whose object is to hold down the first phalanx firmly, so that the powerful flexor longus hallucis, acting on the second, exerts all its influence on a straight great toe.

Fig. 769 is introduced here to remind the student of the arrangement of the **superficial lymphatics of the lower extremity.**

These follow chiefly the saphena veins, and enter the inguinal (page 667) and popliteal glands. The superficial lymphatics of the buttock enter the outer, and those over the adductor muscles the innermost group of the inguinal glands.

The deep lymphatics of the lower limb, comparatively few in number, follow the course of the deeper vessels. After passing through some four or five glands deeply placed about the popliteal vessels (these glands also receive the lymphatics along the external saphenous vein) the lymph is carried up by lymphatics along the femoral artery to the deep femoral or inguinal glands. These are found around the upper part of the femoral vessels; one very often occupies the femoral canal.

Fig. 770 shows the distribution of the **superficial nerves** on both aspects of the limb.

THE REGIONS OF THE ABDOMEN

By WILLIAM ANDERSON, F.R.C.S.

As the plan of segmenting the ventral surface of the abdomen by means of two horizontal and two vertical or nearly vertical lines, has survived the test of time, it might be assumed that it is a resource of some practical value to the physician and surgeon. It is, however, a curious fact that, although the nine historical regions of the abdomen have been universally accepted in British and continental schools for at least forty years, and may be traced back to a very much more remote period, no attempt has ever been made to secure uniformity in the plan of their delimitation. Almost every anatomical writer has, in fact, elected to follow a system of his own, with the result that there are at the present moment nearly a score of different schemes in our recognised text-books. There is little doubt that it were better to abandon altogether the pretence of a regional subdivision than to employ terms which have no scientific meaning, but it may be hoped that some accord will soon be arrived at.

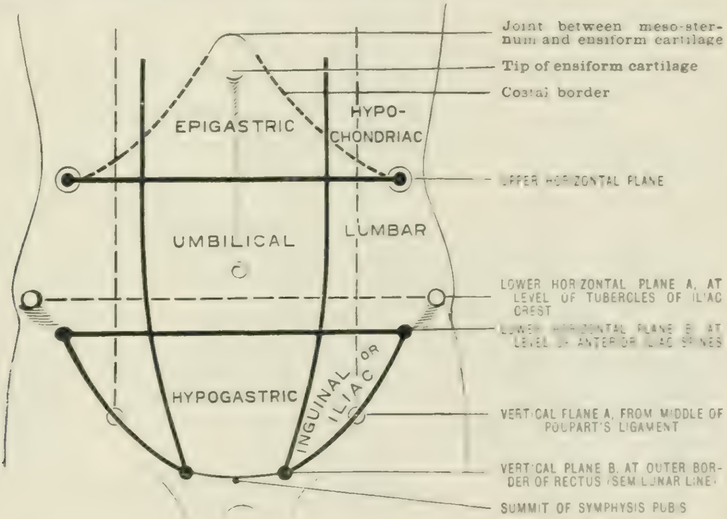
Whatever system be adopted, it is necessary that the boundary 'lines' should be converted into planes carried through the whole depth of the abdomen, and defined on the dorsal as well as on the ventral surface of the trunk, and that the structures cut through by these planes should be noted, as well as those comprised within the regions which they separate. It should, of course, be recognised that the relations so defined can only be approximate, on account of the wide range of physiological variation in the position of the abdominal contents; but this being understood, a regional type would be of material service in medical education.

If we retain the subdivision into nine segments, it remains only to consider the method of delimitation. Firstly, for the *higher horizontal plane*, the most suitable level appears to be the lowest point of the tenth costal cartilage. This plane passes through the second lumbar vertebra posteriorly, and lies about two inches above the umbilicus in front. It cuts through the stomach, the transverse colon, the ascending and descending colon, the duodenum (lower curvature) and small intestine, and the kidneys. For the *lower horizontal plane* we have the choice of two levels—that of the anterior superior iliac spine, which lies about an inch below the level of the sacral promontory, and that of the tuberculum cristæ, recently proposed by Professor Cunningham.

The plane of the tuberculum cristæ (*intertubercular plane*) has been adopted by Quain and Cunningham; but the lower of the two alternative planes, that of the anterior iliac spines, seems the more definite and convenient for clinical demonstration.

This *interspinous plane*, carried horizontally backwards from the symphysis into the true pelvis, cuts the small intestine, the cæcum or lower part of the ascending colon, the sigmoid flexure, the upper end of the rectum, the fundus uteri, the ovaries and Fallopian tubes, and the distended bladder, and hence forms a valuable guide to the surgeon.

FIG. 771.—DIAGRAM OF THE ABDOMINAL REGIONS.


Joint between meso-sternum and ensiform cartilage
Tip of ensiform cartilage
Costal border
EPIGASTRIC
HYPO-CHONDRIAC
UPPER HORIZONTAL PLANE
UMBILICAL
LUMBAR
LOWER HORIZONTAL PLANE A, AT LEVEL OF TUBERCLES OF ILIAC CREST
LOWER HORIZONTAL PLANE B, AT LEVEL OF ANTERIOR ILIAC SPINES
HYPOGASTRIC
INGUINAL OR ILIAC
VERTICAL PLANE A, FROM MIDDLE OF POUPART'S LIGAMENT
VERTICAL PLANE B, AT OUTER BORDER OF RECTUS (SEMILUNAR LINE)
SUMMIT OF SYMPHYSIS PUBIS

For the *longitudinal plane* on each side, that corresponding to the 'vertical line' of Quain, running upwards parallel to the mesial line from the middle of Poupart's ligament, is already familiar to the greater number of observers; but it has the disadvantage of making the mesial regions very large in proportion to the lateral regions, the upper lateral regions being still further reduced in women owing to the narrowness of the chest when compared with the width of the pelvis. As an alternative, the outer border of the rectus would be preferable, as it is usually to be localised without difficulty by the lateral infracostal furrow above, and by the pubic spine below; and when these points are indistinct, the breadth of the patient's hand at the head of the metacarpal bones may be taken as equal to the breadth of the rectus in its upper two-thirds. This plane, while reducing the width of the middle zone without interfering materially with existing indications of contents, leaves an *inguinal region* that includes the whole of the inguinal canal. Each plane cuts the kidney, transverse colon, and small intestine, and the *ovaries* lie at or near its intersection with the lower horizontal (interspinous) plane; the *right* plane cuts also the gall bladder, and sometimes the cæcum; the *left* cuts the sigmoid flexure, the stomach (great *cul-de-sac*), the pancreas, and the spleen. The subjoined table will show the contents of the regions adjusted according to this scheme. If the vertical plane from the middle of Poupart's ligament be preferred to that here adopted, the name of '*iliac*' region must replace that of '*inguinal*,' and the two inguinal canals would be transferred to the hypogastric region. The choice of the intertuberculous plane in place of the interspinous plane affects the table chiefly in bringing the lower part of the ascending colon into the right 'iliac' region.

The subjoined diagram shows the two principal schemes, and the table offers a summary of the visceral contents:

The Abdominal Viscera regionally arranged.

Right		Middle		Left
Hypochondriac		*Epigastric*		*Hypochondriac*
Liver: portion of right lobe (gall bladder usually cut by longitudinal line). *Kidney:* upper and outer part. *Colon:* hepatic flexure and part of ascending colon.	*Longitudinal plane along outer border of rectus*	*Liver:* quadrate, caudate, Spigelian, and greater part of left lobes (gall bladder usually cut by longitudinal line). *Pancreas:* head and body. *Spleen:* upper and inner part. *Kidneys:* upper and inner part of each, with pelves. *Suprarenal bodies.* *Stomach:* middle and pyloric regions, cardiac and pyloric orifices. *Duodenum:* first and second portions and termination of third portion. *Small intestine:* transverse colon, variable portion.	*Longitudinal plane along outer border of rectus*	*Liver:* portion of left lobe. *Spleen:* lower and outer part. *Pancreas:* tail. *Kidney:* upper and outer part. *Stomach:* great *cul-de-sac.* *Colon:* splenic flexure.
		Upper horizontal plane at level of lowest point of costal border		
Lumbar		*Umbilical*		*Lumbar*
Kidney: lower and outer part. *Ascending colon.* *Cæcum:* portion or whole. *Small intestine:* chiefly ileum.		*Kidneys:* lower and inner portion of each, with ureters. *Duodenum:* lower flexure and part of third portion. *Jejunum* and *ileum.* *Transverse colon:* portion. *Sigmoid flexure* and commencement of *rectum.*		*Kidney:* lower and outer part. *Small intestine:* chiefly jejunum. *Descending colon* and portion of *sigmoid flexure.*
		Lower horizontal plane at level of anterior superior iliac spines carried into true pelvis		
Inguinal		*Hypogastric*		*Inguinal*
Small intestine. *Cæcum:* lower portion, occasionally. *Inguinal canal.*		*Small intestine.* *Sigmoid flexure* and *rectum* (portion). *Cæcum:* lower portion, occasionally. *Ureters.* *Bladder:* in children, and distended bladder in adults. *Fundus uteri* and appendages.		*Small intestine.* *Sigmoid flexure:* portion. *Inguinal canal.*

SECTION XI

VESTIGIAL AND ABNORMAL STRUCTURES

By ARTHUR ROBINSON, M.D., M.R.C.S.

LECTURER ON ANATOMY IN THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; EXAMINER IN ANATOMY FOR THE CONJOINT BOARD OF ENGLAND

The **vestigial structures** met with in the human body may be classified in two groups:—

(1) Remnants of organs which played an important part during fœtal life.

(2) Structures which appear regularly in the human body, but which possess little or no function, being merely vestiges of organs which are much better developed in some of mankind's ancestors.

The **abnormal structures** which occasionally appear in the human subject are produced by retardation or excess of ordinary developmental processes, by the non-union of parts which usually fuse together, by the fusion of parts which usually remain separate, or the formation of organs not usually developed in man, but which are, however, frequently met with in some of his more or less remote ancestors; organs of the latter class are of atavistic nature, that is, they are due to a 'reappearance of a more primitive organisation, or a reversion to a primary state.'

THE SKELETON

THE SKULL

The epipteric bone.—This term was applied by Professor Flower to a small bone occasionally found at the bottom of the temporal fossa, separating the great wing of the sphenoid from the anterior inferior angle of the parietal bone. It is of the nature of a Wormian bone, and is due to the appearance of a centre of ossification in the region usually occupied by a portion of the parietal bone or the great wing of the sphenoid.

The interparietal bone, or os Incæ, and the præinterparietal bone.—The posterior section of the occipital bone, the squama occipitalis, is usually developed from at least three pairs of centres, which are superposed. As a rule, each pair of centres soon fuses into a single nucleus of ossification, and the three segments of bone formed from the three pairs of centres fuse together to complete the squama occipitalis.

Occasionally, however, the two upper segments may unite, but remain separate from the lower segment, and then, in the adult, a bone is found lying between the parietal bones and above the occipital. This bone is known as the interparietal bone, or, because it appears more frequently in ancient Peruvian skulls (five to six per cent.) than in European skulls (one to two per cent.), it is also called the os Incæ.

The interparietal bone may consist of lateral halves, a condition produced by the centres on each side failing to unite across the middle line.

In a relatively small number of cases the upper segment alone may remain separate in adult life as a præ-interparietal bone, which corresponds in position with the apex of the occipital bone: this also may consist of two lateral segments. In a still smaller number of cases both interparietal and præ-interparietal bones may be present in the same skull.

The interparietal bone appears first among mammals, and is best developed in some of the lower forms. The præ-interparietal bones are only constantly present in the horse.

Fontanelle bones.—Accessory centres of ossification occasionally appear in the membranous wall of the skull in the regions of the anterior and posterior fontanelles, where they give rise to small segments of bone, which remain separate throughout life. The anterior fontanelle bone lies in the region of the bregma, between the parietals and the frontal, and the posterior fontanelle bone is situated at the lambda, between the parietals and the occipital. Both are of the nature of Wormian bones, and the posterior fontanelle bone must not be confounded with the præ-interparietal bone.

Os Japonicum.—This term has been applied to a malar bone, which consists of two separate fragments, under the idea that a bifid condition of that bone is more common in the Japanese than in other races; but a double malar bone is not unfrequently met with in other races, and its significance is not at present thoroughly understood.

THE STERNUM

Cleft sternum.—Occasionally the sternum, instead of being a single median bone, consists of two lateral parts, each part being connected with the cartilages of the true ribs of its own side. This condition is due to the persistence of one of the embryological phases through which the sternum normally passes, for in the early periods of development each half of the sternum is formed by the fusion of the cartilaginous extremities of the upper nine ribs, and thereafter the two cartilaginous bars thus produced fuse together to form the single median sternum with which the eighth and ninth ribs subsequently lose their connection. If the fusion of the two halves of the cartilaginous sternum does not occur, ossification proceeds in each half, and the condition of cleft sternum is produced.

Perforated sternum.—Not unfrequently an aperture, of larger or smaller size, is found in the lower part of the body of the sternum. It is filled, in the recent condition, by fibrous tissue or by cartilage, and it is due to the non-union of the lateral centres of ossification from which the lower part of the sternum is ossified.

Ossa suprasternalia.—The two small bones or round nodules of cartilage which are known as the ossa suprasternalia, or Brecht's cartilages, are found, one on each side, above the sternum and immediately internal to the sterno-clavicular joint. They are to be looked upon as rudiments of the episternal bone, which is met with in so well-developed a form in the ornithorhynchus.

THE RIBS

Additional ribs.—There are usually twelve pairs of ribs in the human subject, but there is embryological evidence to show that man has inherited a larger number from his predecessors. Therefore the occurrence of additional ribs is an atavistic phenomenon. In the embryo rudiments of additional ribs are found both at the upper and lower ends of the ordinary series,—at the upper end in connection with the last two cervical vertebræ, and at the lower end in connection with all the lumbar and sacral vertebræ. In the adult, however, additional ribs are only met with in connection with the last cervical and the first lumbar vertebræ. The cervical rib has been found extending from the seventh cervical vertebra to the sternum. As a general rule, however, it terminates anteriorly by joining the first rib, or only its anterior and posterior ends are formed, the two parts being connected by a band of fibrous tissue. The lumbar rib, when it appears, always terminates by a free end in the body wall.

UPPER LIMB

HUMERUS

The supracondylar process and foramen.—When it is present, the supracondylar process springs from the inner surface of the humerus, a few centimetres above the internal condyle; it turns downwards, and is united to the humerus at a lower level by a band of fibrous tissue, which is sometimes replaced by bone. In the latter case, a distinct supracondylar foramen is formed, through which the median nerve passes. This foramen is very common in the lower mammals, in amphibians, reptiles, and in their fossil ancestors.

The supratrochlear foramen.—This foramen is formed when the septum between the coronoid and olecranon fossæ is not developed. It is frequent in the lower races of mankind, especially in the South African natives and in the Veddahs. It also occurs in skeletons belonging to the Stone Age, in the gorilla, the orang, and the lower apes.

The os centrale.—The os centrale is occasionally found as a separate bone in the carpus, lying in an interval between the scaphoid, the os magnum, and the trapezoid and trapezium. Its cartilaginous rudiment is always present at the second month of fœtal life, but in the second half of the third month it usually fuses with the scaphoid, and it is only when the cartilage remains distinct and undergoes separate ossification that an os centrale is present in the adult.

The os centrale is a normal component of the carpus of the orang; it is present in most monkeys, and it is a regular carpal element in many of the lower vertebrates.

THE LOWER LIMB

The third trochanter.—In about thirty per cent. of European skeletons the upper part of the gluteal ridge is developed into a prominent third trochanter. This prominence is more rare in negroes and anthropoid apes, but it is very frequently present in lemurs. It is well developed in many of the lower mammals, and it forms a prominent projection on the femur of the hare.

THE MUSCULAR SYSTEM

(*A List of Abnormal Muscles will be found on page 458.*)

THE NERVOUS SYSTEM

The filum terminale.—Extending from the end of the conus medullaris of the spinal cord to the back of the coccyx there is a thin, cord-like structure, the filum terminale; it forms part of the cauda equina, and is the lower, non-functional portion of the spinal cord. It does not exist before the third month of fœtal life, for up to that period the spinal cord is coextensive with the spinal canal. After the third month, however, the lower part of the spinal cord ceases to develop in the same matter as the upper part; at birth the functional part of the spinal cord terminates at the third lumbar vertebra, and in the adult it ends at the level of the second lumbar vertebra, the terminal or caudal portion of the cord, which is better developed in many vertebrates, being represented in man by the filum terminale. This retrogression of the lower part of the cord is not, however, confined to man, for it is present also in other mammals, and it is particularly well marked in the hedgehog, the filum terminale commencing in this animal in the anterior part of the thoracic region.

In the human adult the filum terminale is about 23 cm. (9 inches) long, and it is divisible into two parts—an upper, about 14 to 15 cm. (6 inches) long, which lies in the subdural space, and a lower part, about 7 cm. (3 inches) long, which is closely invested by a covering of dura mater. The first part consists, at its commencement, of an outer layer of nerve-fibres, the fibres of the coccygeal and accessory coccygeal nerves (thirty-first, thirty-second, and thirty-third pairs of nerves), a small amount of grey matter, some substantia gelatinosa centralis, and the lower part of the central canal. The central canal terminates about 4 cm. beneath the conus medullaris, the grey matter about 8 cm. below the same point, and the remainder of the first part of the filum consists, therefore, merely of a few nerve-fibres and connective tissue. The nerve-fibres of the thirty-second and thirty-third pairs of nerves are quite functionless, and they disappear after a very short course in the second part of the filum, the lower portion of which consists entirely of strands of connective tissue more or less separated from each other, and attached at intervals to the back of the coccyx.

The pineal body.—This structure, which appears at an early period in the development of the fœtus, is a diverticulum from the roof of the primitive fore-brain, or thalamencephalon; it grows backwards, and in the adult lies between the splenium of the corpus callosum and the anterior quadrigeminate bodies, embedded in a fold of pia mater. It never attains a high grade of development in man, nor, in him, does it appear to possess any special functions, but in some of the lower vertebrates it appears to serve the purpose of an unpaired median eye, and, reaching the surface of the body, it is embedded in the parietal foramen in the skull wall. In the higher vertebrates, however, including man, it is displaced from a superficial position by the great development of the cerebral hemispheres.

The pituitary body.—The pituitary body is connected in the adult with the floor of the third ventricle, and it is embedded in the pituitary fossa of the sphenoid bone. It consists of two lobes—an anterior, of somewhat glandular nature, and a posterior, in which remains of nervous structures can sometimes be recognised. The posterior lobe is formed by an outgrowth from the floor of the thalamencephalon, and in man and other mammals the anterior lobe is a diverticulum from the roof of the stomatodæum, or primitive mouth, but in the lower vertebrates the anterior lobe is formed by a diverticulum from the olfactory depression, and consequently its origin in man is a secondary one.

The history of the pituitary body has not yet been fully elucidated, but it is believed that it represents the remains of the ancestral mouth, and that the mouth which is now formed has been developed by the fusion of a pair of gill clefts.

THE EYE

The canal of Cloquet or Stilling.—Almost in the axis of the eyeball there is a fine canal passing through the vitreous body from the optic papilla to the back of the capsule of the lens; this is the canalis hyaloideus, or the canal of Cloquet or Stilling. It is lined by a fine homogeneous membrane, and in the adult it may possibly serve as a lymph passage, but in the fœtus it transmitted the capsular branch of the central artery of the retina from the optic papilla to the back of the lens capsule, which at that time was a very vascular structure.

The plica semilunaris.—At the inner canthus of the palpebral fissure there is a small fold of conjunctival membrane, the plica semilunaris. In many negroes it contains a small plate of cartilage, and it represents the third eyelid, or nictating membrane, of birds, many reptiles, and some amphibians. The function of the third eyelid is to cover and cleanse the front of the eyeball, but this function is performed in man by the upper eyelid, and consequently the nictating membrane remains as a rudimentary fold.

VASCULAR SYSTEM

The foramen ovale.—This aperture is found in the interauricular septum, at the upper part of the fossa ovalis. It is a remnant of a much larger aperture, which existed before birth for the passage of blood from the inferior vena cava directly into the left auricle. At birth, when the lungs become functional, the inferior vena cava blood is diverted into the right ventricle, and in the majority of cases the foramen ovale soon closes, but in one case in five the upper part remains open in adult life.

The sulcus terminalis and crista terminalis.—Upon the anterior surface of the right auricle there is a shallow sulcus, the sulcus terminalis, which extends from the front of the lower end of the superior vena cava to the right of the termination of the inferior vena cava, and upon the inner surface of the auricular wall, in a similar position, there is a ridge, the crista terminalis, in which the upper ends of the musculi pectinati terminate. Both these structures indicate the line of union of the posterior portion of the primitive heart, the saccus reuniens or sinus venosus, with the second portion or auricle.

The ligamentum arteriosum.—This term is applied to a fibrous cord which connects the root of the left pulmonary artery to the under surface of the arch of the aorta, intervening between the superficial cardiac plexus on the inner side and the left recurrent laryngeal nerve on the outer side. It is the remnant of the dorsal part of the left fifth aortic arch, one of a series of vessels arranged in pairs between the ventral and dorsal parts of the aorta of the fœtus. When the fœtal blood-channels are transformed into the permanent vessels of the adult, the ventral parts of the fifth arches become the roots of the pulmonary arteries, the dorsal part on the left side soon disappears, but the dorsal part on the right side persists till birth, and through it blood passes from the right ventricle into the aorta. After birth, when the blood of the right ventricle is diverted into the lungs, the dorsal part of the left fifth arch loses its lumen and is converted into a fibrous cord.

The obliterated hypogastric arteries.—The fibrous cords which are known as the obliterated hypogastric arteries are easily seen when the abdomen is opened and the intestines are lifted out of the pelvis. Each cord extends from the anterior part of the upper extremity of the internal iliac artery, under cover of the peritoneum, and beneath the ureter and the vas deferens, or the round ligament of the uterus, according to the sex, to the posterior surface of the anterior wall of the abdomen, where it ascends with an inward inclination across Hesselbach's triangle and behind the lower part of the rectus abdominis muscle, to join the urachus a short distance above the apex of the bladder; both the cords then ascend with the urachus to the umbilicus, where they terminate in the cicatrix. They are the remnants of the ventral portions of two large arteries, the umbilical arteries, which conveyed blood to the placenta and which formed during the greater part of inter-uterine life the main continuations of the aorta. The dorsal portions of the umbilical arteries become the common and internal iliac arteries, and after birth, when the placental circulation ceases, the ventral parts are converted into fibrous cords.

The round ligament of the liver.—This ligament is a round, fibrous cord, which extends from the umbilical cicatrix along the lower or free border of the falciform ligament to the anterior end of the longitudinal fissure, and thence along the anterior part of the longitudinal fissure to the left extremity of the transverse fissure, where it terminates by fusing with the anterior wall of the left branch of the portal vein. It is the remains of the left division of the umbilical vein, a large vessel which returns the blood from the placenta and which divides at its entrance into the body into right and left branches; the right branch disappears at an early period of development, but the left persists until the placental circulation terminates at birth, when it is converted into a solid fibrous cord.

The ligamentum venosum.—The ligamentum venosum is a fibrous cord situated in the posterior part of the longitudinal fissure of the liver. It springs from the posterior wall of the left branch of the portal vein, somewhat to the right of the termination of the round ligament anteriorly, and it terminates above in the inferior vena cava. It is the remains of a channel, the ductus venosus, which persists until birth for the transmission of the greater part of the placental blood directly from the left umbilical vein to the inferior vena cava.

The vestigial fold of the pericardium.—The vestigial fold of the pericardium, which was first described by Marshall, extends from the left branch of the pulmonary artery to the left superior pulmonary vein. It contains a fibrous cord which represents the lower part of the left superior vena cava, a vessel which is very common in mammals generally, but which is generally absent in man.

GENITO-URINARY SYSTEM

FEMALE

The round ligament of the uterus and the ligament of the ovary.—When the ovary is developed, in the lumbar region of the abdomen, it is connected with the labium majus and the lower part of the anterior abdominal wall by a musculofibrous cord, the gubernacular cord of the ovary, which corresponds with the gubernacular cord of the testicle in the male. The male gubernacular cord completely disappears when the testicle is pulled down into the scrotum, but the gubernacular cord in the female contracts to a smaller extent, and the ovary is only pulled down to the back of the broad ligament. As soon as the contraction has proceeded to this extent, the gubernacular cord becomes attached to the side of the uterus below the Fallopian tube, the portion of the cord in front of the attachment becoming the round ligament of the uterus, whilst that behind is converted into the ligament of the ovary.

The hydatid of Morgagni.—The hydatid of Morgagni is a small pyriform vesicle attached to the upper border of the broad ligament of the uterus, or to one of the fimbriæ of the Fallopian tube, by a slender pedicle. It is usually filled with clear fluid, and it is the modified remnant of one of the Wolffian tubules of the primitive kidney.

The epoophoron, epovarium, or organ of Rosenmüller.—This rudiment of the primitive kidney, or Wolffian body, lies in the broad ligament of the uterus, between the ovary below and the Fallopian tube above. It consists of a series of from twelve to twenty vertical tubules, which commence below in or near the hilum of the ovary, and terminate above in a horizontal tubule which lies parallel with, and a short distance below, the Fallopian tube. The vertical tubules are remains of the upper Wolffian tubules, and they correspond with the vasa recta and the vasa efferentia of the testicle. The horizontal tube is a remnant of the upper part of the Wolffian duct, and it therefore corresponds with the tube of the epididymis in the male.

The paroophoron, or parovarium.—The paroophoron lies in the broad ligament of the uterus to the inner side of the epoophoron and the ovary. It consists of a number of yellow cords, the remnants of some of the lower Wolffian tubules, and it is homologous with the organ of Giraldès in the male. It cannot always be recognised, and as a rule it is only present during childhood, disappearing before adult life is attained.

The duct of Gärtner.—The duct of Gärtner is a small tube, blind at both extremities, which is occasionally found at the side of the neck of the uterus and the upper part of the vagina. It represents a section of the lower part of the Wolffian duct, and corresponds with a portion of the vas deferens of the male.

MALE

The hydatids of Morgagni.—Two hydatids of Morgagni are met with in the male—the pedunculated and the sessile. The former is very inconstant; when present it is an oval or pyriform vesicle, filled with clear fluid, which is attached by a slender pedicle to the globus major of the epididymis. It corresponds with the hydatid of Morgagni met with in the female, and it is the remnant of one of the upper Wolffian tubules. The sessile hydatid is more frequently present. It is also an ovoid vesicle, which is attached by its small end to either the upper extremity of the testicle or to the groove between the testicle and the globus major. It corresponds with the fimbriated end of the Fallopian tube in the female, for it is a remnant of the upper end of the Müllerian duct from which the Fallopian tube is developed.

The organ of Giraldès, or parepididymis.—This organ is a remnant of some of the lower Wolffian tubules, and it corresponds with the parovarium of the female. It lies in front of the lower part of the spermatic cord, above the epididymis, and either behind the upper part of the tunica vaginalis or just above it. The tubules of which it consists are small, yellowish in colour, and they are coiled together, forming a small body, which is from 5 to 14 mm. in diameter (½ of an inch).

Vasa aberrantia.—When the tube of the epididymis is uncoiled, several blind diverticula are found connected with it. They constitute the vasa aberrantia, and the largest of them, which is usually found in the region of the globus minor, is known as the vas aberrans of Haller. It varies in length from 4 to 37 cm. (1½ to 15 inches), and it is coiled into the form of a small mass 2 to 6 cm. (¾ to 3 inches) long, which lies between the body of the epididymis and the vas deferens. The exact significance of the vasa aberrantia is not certain, but they are probably the remains of some of the Wolffian tubules.

The uterus masculinus, or sinus pocularis.—The uterus masculinus lies in the floor of the prostatic portion of the urethra, where it opens, immediately in front of the highest point of the verumontanum, by an oval opening. It is a small cavity, 6 to 12 mm. (¼ to ½ of an inch) long, narrow at its opening into the urethra, but it widens considerably towards its blind extremity. It lies behind the middle lobe of the prostate gland and between the lateral lobes and the common ejaculatory ducts. It is a remnant of the lower parts of the Müllerian ducts, from which the uterus, vagina, and the Fallopian tubes are developed in the female, and it corresponds, therefore, with the vagina, and possibly with the uterus of the female.

INTEGUMENT

Hypertrichosis.—The condition of excessive hairiness to which the term hypertrichosis is applied only occurs occasionally, and it may be due either to the excessive development of the secondary hairy covering which develops after birth,—hypertrichosis vera,—or to the persistence and growth of the woolly covering or lanugo which is formed over the surface of the body during intrauterine life, and which is usually cast off to make way for the secondary hairs. This latter condition is called pseudohypertrichosis lanuginosa.

Supernumerary breasts and teats.—The occurrence of additional teats—polythely—and additional mammæ—polymasty—is by no means uncommon, the percentage of cases of additional mammary structures varying in different districts from one-half to thirty per cent.

To understand the position in which the majority of additional mammary organs are found, it must be remembered that in many mammals the mammary glands are developed as thickened ridges of epithelium, which extend from the axillæ to the groin. Subsequently the ridges are broken up into separate patches, each of which is capable of development into a distinct gland.

Embryonic mammary ridges have not yet been found in human embryos, but the majority of additional mammæ appear along lines extending from the axillæ to the groins,—that is, along the lines where we should expect the mammary ridges to be formed during embryonic life,—and additional mammary glands or nipples appearing along these lines must be looked upon as of atavistic nature, inasmuch as they are indications of a reversion to a more primitive organisation. By the careful observation of a large number of cases it has been shown that along a line running from the axilla to the groin, on each side, ten mammary glands may be found in the human subject, and of these the normal gland is the sixth. The complete series does not occur in any one case, and more than half the number of accessory mammary organs which have been observed appear below the normal nipple.

In addition, however, to atavistic mammary organs appearing along the lines indicated, mammary glands are occasionally found on the thigh, shoulder, neck, and cheek. Such glands are most probably developed *in situ* by the abnormal modification of cutaneous glands, and in connection with the formation of such abnormal structures it must not be forgotten that all mammary glands are merely modified sebaceous glands.

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[*The principal authority for the derivations of the anatomical terms given in this Index is Hyrtl's 'Onomatologia Anatomica,' Vienna*, 1880.]

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